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Albany Meeting of the American Electrochemical Society.

That the Albany meeting of the American Electrochemical Society would prove highly enjoyable and successful was expected and is only natural. The membership of the society has been drawn together from many different fields, and from the very start the engineers and the scientists, the chemists and the electrical engineers, and the electrochemists proper turned out to be good "mixers," and a strong sentiment of professional solidarity now holds the society firmly together. The good and happy feeling which abounded at the meeting was, however, due, to a large extent, to the exceedingly kind manner in which the local members of Albany, Schenectady and Troy cared for their visitors. The attendance was again large, but it would be much larger, if only those who stay away knew what they are missing in a social way. In view of the exhaustive report of the professional proceedings found elsewhere in this issue, we may simply emphasize here the very wide field of different interesting subjects discussed. The program was again crowded, and the presentation of papers, as well as the discussion, had again to be cut short. It is not clear whether this has become a chronic disease or whether it is getting more acute at every meeting. That everything has been going so well under such circumstances is a credit to the impartiality, energy and tact of the past presidents. For the first time the society has now, as its president, one of the most representative pioneers of our electrochemical industries, Mr. Edward G. Acheson. The outlook for future growth and usefulness is very bright.

The Carbon Cell.

In the Analysis of Current Electrochemical Patents in this issue a patent for a gas cell is abstracted, which has recently been granted to Mr. E. W. Jungner, best known through his activity on the nickel-iron battery on which he has been working independently of, and contemporaneously with, Mr. Edison. Mr. Jungner's gas cell is interesting for the reason that the reaction in it forms one step of a cyclic process, the total result of which is the complete combustion of carbon, as indicated by the equation $C + O_2 = CO_2$. It is another attempt to utilize the energy of this reaction to perform work by a more economical method than in the usual way of changing all the energy of the reaction into heat and converting a small part of this heat (limited by the second principle of thermodynamics) into work by means of boilers and steam engines. In practice we can change the total energy of every spontaneous reaction into heat. In theory it should be possible to carry out such a reaction in a way so as to perform a certain amount of work; if we carry out the reaction at constant temperature and in a reversible way, we get the maximum work that it is possible to get out of the reaction at all at that temperature. This

maximum work is what Helmholtz called the free energy of the reaction at that temperature.

* * *

The reaction of zinc with copper sulphate goes on spontaneously. If we let it go on by simply putting the zinc into copper sulphate, we get the total reaction energy in form of heat. But if we let exactly the same reaction go on in a Daniell cell at constant temperature we change the free energy of the reaction (which in this case is almost exactly equal to the total energy) into electrical energy and we can convert the latter directly into mechanical work; for instance, by driving an electric motor. The more we avoid the production of Joulean heat, by making the internal resistance of our cell infinitely small, and the more we avoid other complicating phenomena like diffusion (or in other words, the nearer we come to ideal reversibility), the nearer we will be in practice to the ideal goal of getting the maximum possible amount of work out of the reaction.

* * *

The first attempts to utilize the combustion energy of carbon more economically, were made in the direction of the construction of a carbon cell, the general design being suggested by the analogy of the Daniell cell as outlined above. It is fair to acknowledge that these attempts were not foolish, but we must frankly state that all these attempts have failed completely. In our usual terminology the chief difficulty may perhaps be briefly summed up in the statement that it seems impossible in practice to get carbon into the ionic state. When the failure had been recognized, the front of the attack was changed in two directions. Not only the methods of trying to find a solution were changed, but also the problem itself was put in a more general way. The combustion of carbon is not the only chemical reaction which would represent an immense progress if it could be carried out as an electrochemical reaction. To mention only two other reactions which would be very useful, we may refer to the oxidation of aluminium and to the oxidation of iron. As to aluminium, if we imagine an aluminium-iron cell, which would electrochemically reproduce the reaction of Dr. Hans Goldschmidt's thermit process (for instance by trying to build a battery on the general scheme of the Edison nickel-iron battery, but with aluminium and iron oxide as active materials at the beginning of the discharge), we have a delightfully interesting battery, light and of a high e.m.f.—on paper. To anybody who knows anything about aluminium, it is unnecessary to point out the difficulties of such an attempt. Others have tried to utilize the oxidation heat of iron and there is more common sense in such attempts than would appear at first glance. Iron can easily be brought into the ionic state in more than one state of valency; and if the chief reaction of the cell would be the oxidation of iron, the reverse reduction in the blast furnace is cheap. True, any iron battery will have a low e.m.f.

* * *

The methods by which inventors now try to solve problems of this kind, have also changed and broadened. The whole desired reaction is often subdivided into two, one of which is carried out as electrochemical reaction, while the other is a purely chemical reaction, offering no special difficulties. Naturally such processes mean necessarily increased complications and Mr. Jungner's patent is a good illustration of this fact. But we cannot deny the possibility that attempts of this general nature may lead to industrial success. Processes of this kind are theoretically possible and are therefore entirely different, for instance, from schemes to invent a perpetuum mobile. The practical net result of the large amount of work which has been done in the past in the field is emphatic recognition of the practical difficulties. Whether anything of industrial value will develop from this work in future can only be answered by continuing to try and work.

The Essential Details.

To the visitor watching the operation of a large blast-furnace, all seems simplicity and regularity. The ore, coke and limestone are hoisted in the big skips and dumped into the voracious maw with machine-like ease. The tapping of the "cinder" and metal is effected with the precision of a military drill. In the meantime, the "pricking" of the tuyeres, the shifting of the gas from one hot-blast stove to another is done with a languid nonchalance by the various workmen, apparently when they happen to feel like it. It would appear that the furnace ran itself. Everything seems a matter of course. In reality, the case is entirely different. The charges have been designed by the use of exact tables, the deductions of thousands of careful experiments, modified by years of practice. The coke, proper to withstand the crushing load of the "burden," has been found after many experiments. The size and shape of the stack, the quality of the refractory brick, in fact, every detail has been decided on after many hard trials. The construction of the heating stoves has had the benefit of the decisions of thousands of minds, tutored and untutored. Sometimes, the untutored mind, or rather the mind tutored by practical familiarity with the art, has through a happy instinct solved by a simple device the problem which baffled the scientific expert. In fact, the essential details of operation have been evolved by the innumerable trials and failures of iron-workers since the days of Catalan forges to the present. The great furnace is an evolution of experience, a survival of the tested. Behind it lies many generations of the gradual destruction of the unfit. But the visitor cannot see the unsuccessful, any more than we can see in the orderly working of a court of law, the long line of tyranny, rapine and injustice, by the gradual weeding out of which our modern system of jurisprudence has been finally evolved.

* * *

So any new process in metallurgical practice is the result not only of the grouping of a few broad principles, but also of the fitting in of the complex of many little essential details, the result of the winnowing out of the unsuccessful. The process is held together as a practical unity because these details have been worked out by trial on a sound basis and bind together the underlying germinal scientific ideas as cement motar does the bricks and stones of an edifice. No one has more respect for the fecundity of a scientific idea than this journal. But we know that the successful growth of the two-germ cells depend on the proper environment in which they can draw to themselves thousands of cells of an inferior order and build up an

organic structure. Thus in metallurgical development, the realization of any invention is attained only by the welding of sound theoretical conceptions by numerous little details derived from new practical experience. Lack of comprehension of this necessary complexity has led to undue hope, to undeserved disappointment and to the halting and sometimes the failure of many meritorious inventions. Appreciation of it will make the inventor be sure he is right and then go slow. Some points which are scientifically correct will prove impossible of embodiment. Others with which he expected trouble will solve themselves with ridiculous ease and disappear as difficulties. For he is engaged in the construction of a unity in which the little details are as essential as the underlying germinal principles to which he is attempting to give an embodied life. The conception of an idea may be rapid, its gestation long, and the longer in proportion to its worth.

The Technique of Electrolytic Copper Refining.

The article of Mr. F. D. Easterbrooks in our last issue, on the power plant of the new addition of the Raritan Copper Works, is followed in our present issue by an article of the same author on the new electrolytic refining plant and copper furnaces of these works. These two interesting and able articles give a clear picture of the magnitude and importance of the work involved in the extensions under discussion. It is manifest that a high order of engineering ability and technical knowledge was required in the design and construction of the plant. The investment in a modern copper refinery is large, and the item of depreciation—so fundamentally important in all engineering work—looms high. Particularly in the tank house, since, in view of handling the hot acid solutions, the life of the tanks must be limited and the depreciation charges high, even with the best possible mechanical arrangements. While methods of mechanical handling decrease the labor cost, they increase the depreciation charges. The average life of refining tanks is not known and is estimated differently. We have heard the life estimated as ten years and even six years, though at a visit in 1904 to the pioneer copper refinery of this country, the Balbach works at Newark, N. J., the superintendent of the plant, Mr. F. A. Thum, showed to the writer a series of tanks which had been in operation since the beginning in the early eighties.

* * *

With respect to investment, it is interesting to compare the series system and the multiple system. The investment in the series plant is smaller. First, the investment in power plant is less, because the power required per pound of copper is only about 70 per cent of that in the multiple system, there being practically no contacts or conducting bars and the electrodes being very close together. Further, there is much less copper tied up in the process with the series system than with the multiple system. Finally, with respect to the size of the wire bar furnaces, the fact must be taken into consideration that the cathodes, being much smoother with the series system, can be packed more closely together in the furnace for making wire bars. A certain weight of cathodes, therefore, requires a smaller furnace volume, so that the investment in, and upkeep of, the wire bar furnaces is less per unit weight of copper. These different factors contribute to a smaller investment in the series plant and thereby diminish the fixed charges; and it is quite probable that these advantages had to be paid for in as much as probably greater difficulties had to be overcome in working out the essential fundamental principles for practice with the series system than with the multiple system. Of course, there is also a reverse side of the picture.

* * *

An important point in favor of the multiple system is that in the case of the series system the anodes, which are thin, even plates, close together, must either be rolled or specially hand-cast. The casting of the anodes with the multiple system is much simpler; mining companies, large producers, can and often do cast their copper directly into anode form and ship them as anodes to the refinery. Further, the series system requires much closer supervision to keep the quality of the cathodes up, resulting again in increase of labor cost. Then, in view of the comparatively high voltage employed, it is not possible to use lead-lined tanks in series plants, which means a considerable increase of cost of tank maintenance over the multiple system. In all these different respects the cost of operation is therefore higher with the series than with the multiple system.

* * *

A word may finally be said as to the current density employed. On account of the necessity of getting smoother cathodes in the series system, no such high current density can be used as in the multiple system. This has an influence on the power required, since, other things being equal, an increase in current density decreases the power per unit of weight, as a direct consequence of Faraday's law. But other things are not equal in a comparison of the series system and the multiple system, and as we saw before, for other reasons the power cost is very essentially lower with the series system than with the multiple system with the same current density. However, the necessity of holding the current density below a certain limit in the series system and the possibility of passing far beyond this limit in the multiple system is a point of greatest importance. It means that the multiple system has possibilities which the series system has not. Not only does the power required per unit of weight of copper go down with an increase of current density, but the whole output of copper is directly proportional to the current density according to Faraday's law. With respect to pushing the output of the works to the limit, the multiple system, therefore, offers possibilities which we have not with the series system. From this point of view, any inherent disadvantages of a high current density will be found rather insignificant, like the effect on silver loss. It is true that the higher the current density, the more active must be the circulation of the electrolyte and the greater will be the danger to stir up the silver mud and loose silver which passes into the cathodes. In this respect the relatively low current density of the series system is a certain advantage. In the whole, it is not easy to balance against each other the relative advantages of the two systems. It is, however, a suggestive fact that both systems are commercially successful on a large scale and have been so for years; it is also significant that the American Smelting & Refining Co. are now operating under the same general manager their multiple-system plant in Maurer and their series-system plant in Baltimore, though it is also a fact that by far the largest portion of copper in this country and elsewhere is refined by the multiple system.

Summer Meeting of American Chemical Society.

The 38th general meeting of the American Chemical Society will be held in New Haven, Conn., June 30, July 1 and 2.

The society will, as usual, meet in sections on account of the large number of papers to be presented. The sections will meet in the lecture rooms of the Sheffield Scientific School of Yale University, and will be under the chairmanship of the following members:

Agricultural and food section, A. L. Winton; biological and sanitary section, Thomas B. Osborne; physical section, Frank B. Cameron; organic section, William McPherson; inorganic section, Philip E. Browning; industrial section, William D. Richardson.

Papers intended for these sections must be sent to the chairmen or to Dr. Charles L. Parsons, secretary, New Hampshire College, Durham, N. H., before June 10.

A division of industrial chemists and chemical engineers will be organized at this meeting, and a large attendance is expected.

Programs will be sent all members on June 20. Hotel headquarters will be at the New Haven House.

American Institute of Chemical Engineers.

The committee appointed at Atlantic City last June to consider the formation of an American Institute of Chemical Engineers has found, after obtaining the views of the chemists of this country, that there is a strong sentiment for bringing together into closer relationship those men who more particularly specialize in chemical engineering. A very decisive vote has been received in favor of the formation of the society. It has been decided to call a meeting for the purpose of organization. This will be held in Philadelphia some time during the middle of June. Several men eminent in the profession have consented to address the meeting. Mr. W. M. Booth, Dillage Building, Syracuse, N. Y., is the temporary secretary.

American Foundrymen's Association.

This year's convention will be held in Toronto, Ont., Canada, from June 8 to 10, and a very elaborate program of professional discussions and lectures has been arranged, as well as a fine exhibition. The American Brass Founders' Association, the Associated Foundry Foremen and the Foundry Supply Association will join the American Foundrymen's Association in this convention and a very large attendance is expected.

German Bunsen Society.

The German Bunsen Society will hold its annual convention this year in Austria's capital, Vienna, from May 28 to 31. A special feature of the proceedings will be the presentation of the Bunsen medal.

The program of papers to be read is exceedingly full. Not less than 50 papers have been announced, of which eight (by Profs. Luther, Trautz, Byck, Stobbe, Schaum, Scheffer, von Hübl, Wiesner) will give concise general summaries of various subjects of photochemistry. The whole first morning section will be devoted to this subject. Other papers announced for the second day will be presented by Prof. Loeb on the chemical effects of the silent discharge, by Prof. Le Blanc on the question whether the law of mass action is valid for the silent discharge, by Prof. Kowalski on photoluminescence, by Dr. Weigert on decomposition of ozone by light, and by Prof. Luthers on the energetics of photochemistry.

Among the other papers on interesting scientific subjects we note the following: Prof. Nernst on the theory of electric irritation of nerves; Dr. Trautz on the application of Nernst's thermodynamical theorem to a new problem of equilibrium; Prof. Bodenstein on gas equilibria; Dr. Bechhold on "the measurement of submicrons and amicrons by the ultrafiltration method"; Prof. Brauner on the rare earth elements in the periodic system; Dr. Paweck on the production of radium from uranium ores, etc.

Of technical and engineering papers we note the following: Dr. Hans Goldschmidt on new thermit reactions; Dr. Herzog on physical and chemical processes in dyeing; Dr. Bechhold on the question whether dyeing is a chemical or a physical process, and Dr. Paweck on metallic electrodeposits as starting material for a new industrial application.

Various visits and inspections will be made and the convention will be closed on Sunday, May 31, by a trip to the Semmering Mountain.

Geheimrat Prof. Dr. Walter Nernst, of Berlin, is the first president of the Bunsen Society. Prof. Wegschneider is the chairman of the local committee in Vienna.

The Iron and Steel Market.

If there has been any change in the demand for finished steel products since last report it has been in the direction of a tapering off in the total. Despite the fact that steel production has been at a rate a trifle less than half the maximum attained last year, the prospects are that the usual summer lull will intervene at an earlier time than usual, thus reducing the production still further.

Pig iron production has undergone a slight diminution from the maximum rate attained this year, which was in March, but is still at the rate of about 14,000,000 tons a year, and this also represents the average rate of production since the beginning of the year. Production last October, the banner month in the industry's history, was at the rate of 28,000,000 tons.

A trifle less than the usual proportion of the pig iron output is going into steel. Early in the year foundry pig iron was accumulating, but it is doubtful if stocks are increasing at the moment, and the maintenance of practically stationary production may indicate a slight gain in consumption by the iron foundries.

Wages.

The Amalgamated Association of Iron, Steel & Tin Workers held its annual convention in Youngstown, O., in May. It controls the majority of the skilled labor in the iron, sheet and tin plate mills west of the Allegheny Mountains, through scales which run from July 1 to June 30. The scales formulated at this convention, for presentation to the manufacturers, are substantially the same as the existing scales. There will probably be no resistance on the part of the sheet and tin-plate mills, but the iron mills will undoubtedly insist upon a reduction. Iron bars have declined in price, while a determined effort has been made to uphold steel prices. Besides this, it is pretty generally recognized that the large advance made in the iron scale last summer, through a reference of the dispute to a conciliation board, was not altogether just. The Republic Iron & Steel Company this spring abrogated the arrangement for a reference of disputes to conciliation, but the Western Bar Iron Association still has a form of reference. The wage organization is so nearly complete in the Central West that the manufacturers would have relatively little difficulty in paying the wages demanded, were competition among themselves the only matter to be considered, but the enormous growth in basic open-hearth steel manufacture has quite changed the complexion of the scrap market. On most grades of scrap there is competition between the open-hearth steel furnace and the iron mill, and as remelting is fundamentally cheaper than reworking through the iron-mill the competition is severe and the wage matter in the iron-mills very important. The present scale is based on $5 a ton for puddling, with advances according to the average selling price of bar iron, whereby since March 1 the rate has been $6.12½. Barring relatively short periods, this is the highest price paid for puddling for more than a quarter of a century.

Ore.

No shipments of Lake Superior ore of any consequence have yet been made. The ore producers recognize that on account

of the large stocks at docks and in furnace yards the present season must, regardless of prices, be a very light one, and as it is desired to introduce the open-shop principle in lake shipping, no serious effort has yet been made to start navigation and it is unlikely that much ore will come down before August 1. Last February it was decided to maintain last season's ore prices through this season, and ore producers have lately reiterated their statements that they intend to do so. Some furnacemen insist, however, that there is a secret understanding that late in the season, when the ore stocks have been worked off, there will be a reduction of 50 cents a ton, making a basis to govern the meager shipments which are expected for this year and furnishing a basis which the ore interests will seek to maintain next season.

PIG IRON.

After the meeting of pig iron and ore interests in New York on May 7 it was formally announced that there were no price agreements on pig iron. This was a fact which the market had been well apprised of for several weeks, as while there was a semblance of an agreement in various districts there was no difficulty in buying iron at a large reduction from the agreed prices. The market has been steadier since this meeting, and enquiry has been larger, while actual sales have shown a slight improvement. In the Central West the market is fairly firm on the following basis, f.o.b. valley furnace: Bessemer, $16; basic, $15; malleable, $15; No. 2 foundry, $14.50; forge, $14. Southern iron is fairly firm at $11.50, Birmingham, for No. 2.

RAILS.

Buying of standard rails continues very light, and specifications on old contracts are coming in rather slowly. The railroads are evidently well satisfied that they can get prompt deliveries any time they want them and are therefore deferring purchases. The Edgar Thomson plant of the Carnegie Steel Company has been in fairly continuous operation, but has been gaited to between 30 and 40 per cent of its normal output. Competition in light rails continues keen between the rerolling mills and the mills making them from new steel, and in a number of cases the latter are meeting the competition of the former, thus doing from $23 to $24, while the official price is $28 on sections 25 and 45 pounds per yard, with extras for lighter sections.

FINISHED MATERIALS.

Demand for wire products has tapered off slightly, after a period in which the wire mills ran to about 75 per cent their normal capacity. In tin plates operations are slightly heavier, as the leading interest has started an additional plant and is now running 213 tin mills, this giving it substantially as large an output as it has ever had. The independents are also running practically full. The mills state that on account of the backwardness of the buying season it will be necessary to maintain substantially the present rate of production through July and August. The steel car plants are doing practically nothing, and demand for car and ship plates is at the lowest possible ebb. Merchant steel bar production is also light, and may not be over 25 or 30 per cent of the normal, while the iron bar mills are slightly exceeding this percentage. Rail production is about 40 per cent of normal.

Billets remain at $28, Pittsburg, with half the freight added for delivery at points taking from $1 to $3 freight from Pittsburg. Sheet bars remain at $29.50, delivered Pittsburg and nearby points, and at $29, Pittsburg, plus half the freight, for most other points. Finished steel products remain on the following basis, Pittsburg:

Beams and channels, 15-inch and under, $1.70.
Plates, tank quality, $1.60 to $1.70.
Steel bars, $1.60, half extras.
Wire nails, $2.05, base.
Sheets, 28 gauge, $2.50.
Tin plates, 100-pound cokes, $3.70.

CORRESPONDENCE.

Mathematics of the Induction Furnace.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—With respect to the critical remarks which have been made on my mathematical theory of the induction furnace (American Electrochemical Society paper, New York meeting, 1907), I may refer to them more in detail in later publications. However, I may state here that practical experience shows a satisfactory agreement with my equations, especially as far as the value of the power factor is concerned. As to the stray flux, I think that my calculations are perhaps still insufficient. But in any case the formulas are a valuable aid for a more extended investigation and a good guide in practical research, having served me to design the furnaces to be installed at the Krupp works in Essen. I trust that their operation in practice will closely agree with the theoretical predetermination.

PARIS, FRANCE. GUSTAVE GIN.

Commercial Electric Steel and Gas Power.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—Since there exists a manifest desire on part of many steel makers to know, not only what the electric furnace *can do* in steel manufacture, but *what it is actually doing in commercial operation*, the annexed table should be of interest.

It is a sheet from the works laboratory, giving the composition of steel made in September, 1907, in regular commercial operation in successive heats at La Praz, France, in the Héroult electric furnace, from cheapest scrap and ore.

The raw material used averages high in phosphorus and sulphur and consists of the cheapest kind of steel and castings scrap obtainable in the local market. As will be noticed from the laboratory sheets, the product made is high-grade tool steel, used by the best works in France and elsewhere.

Nearly a dozen steel plants of good standing are now running the Héroult electric process on a commercially successful basis and their capacity is being constantly increased.

What we principally claim is that we can use the cheapest raw material, making the steel makers practically independent of raw material, no matter where they are located, to produce in the Héroult furnace, as an adjunct to oxidizing furnaces, like basic-open hearth, a purer, better and more uniform material than can be made by any other process.

The additional cost over common open-hearth and Bessemer steel is small, and depends naturally on the cost of power and on the extent to which it may be desirable to purify and refine the product.

Our steel is an absolutely homogeneous product, of a finer grain and tougher, in combination with a greater degree of hardness, owing to its purity and the refining operations it has passed through. As compared with the old crucible process, still employed by most makers of high-grade steel, Héroult electric steel is superior, more uniform and can be produced at much lower cost, while the difference between the electric process and the open-hearth or any other oxidizing furnaces is evident from the essential conditions under which they are operated.

In the Héroult furnace, the oxide of iron is reduced by carbon and the product of reaction, being oxide of carbon, escapes, while in the open hearth, the oxide of silicon and manganese, as a result of the operation, remains mostly in the metal, producing irregularity and weakening the steel.

I have already pointed out in previous articles in this journal the absolute control of carbon by recarburizing in the Héroult furnace and the great advantages of this process in making alloy steels, both in regard to economy and thorough amalgamation and uniform distribution of the alloying elements in the metal bath.

Aside from the general demand by railroads and other large

LA PRAZ WORKS, SEPTEMBER, 1907.

No. of Heat	S.	Ph.	Mn.	C.	Si.
1726	0.005	0.014	0.247	1.130	0.227
1727	0.005	0.013	0.364	0.916	0.196
1728	0.005	0.012	0.273	0.970	0.266
1729	0.008	0.010	0.312	0.815	0.241
1730	0.009	0.008	0.377	1.183	*0.108
1731	0.006	0.010	0.338	0.891	0.184
1732	0.004	0.011	0.286	0.856	0.166
1733	0.007	0.012	0.338	0.900	0.186
1734	0.010	0.011	0.312	0.786	0.217
1735	0.006	0.009	0.273	0.846	0.174
1736	0.004	0.012	0.299	0.885	0.174
1737	0.011	0.011	0.195	0.790	0.141
1738	0.007	0.008	0.247	0.932	0.163
1739	0.005	0.011	0.299	0.843	0.152
1740	0.009	0.011	0.234	0.797	0.164
1741	0.014	0.010	0.312	0.810	0.111
1742	0.007	0.011	0.221	0.929	0.130
1743	0.010	0.011	0.195	0.840	0.151
1744	0.012	0.011	0.273	0.757	0.185
1745	0.002	0.012	0.182	0.958	0.165
1746	0.010	0.009	0.260	0.769	0.165
1747	0.009	0.010	0.208	0.802	0.141
1748	0.013	0.011	0.208	0.874	0.117
1749	0.007	0.012	0.208	0.869	0.152
1750	0.009	0.008	0.273	1.030	0.211
1751	0.011	0.008	0.195	0.850	0.223
1752	0.006	0.006	0.260	0.850	0.223
1753	0.012	0.005	0.221	0.803	0.221
1754	0.006	0.006	0.221	0.760	0.191
1755	0.007	0.011	0.286	0.888	0.134
1756	0.008	0.013	0.208	0.820	0.155
1757	0.006	0.011	0.325	0.882	0.258
1758	0.006	0.008	0.221	0.890	0.178
1759	0.004	0.011	0.338	0.803	0.204
1760	0.008	0.008	0.234	0.757	0.125
1761	0.004	0.008	0.221	1.275	0.138
1762	0.004	0.010	0.286	1.250	0.317
1763	0.007	0.009	0.338	1.095	0.213
1764	0.003	0.008	0.208	1.218	0.176
1765	0.004	0.012	0.247	1.291	0.199
1766	0.005	0.011	0.247	1.181	0.137
1767	0.004	0.012	0.234	1.196	0.221
1768	0.005	0.008	0.208	1.215	0.124
1769	0.006	0.009	0.182	1.209	0.190
1770	0.006	0.011	0.208	1.161	0.152
1771	0.008	0.011	0.260	1.284	0.121
1772	0.005	0.010	0.221	1.208	0.156
1773	0.006	0.008	0.260	1.210	0.199
1774	0.005	0.004	0.208	1.211	0.217
1775	0.006	0.004	0.208	1.198	0.181
1776	0.004	0.011	0.286	1.192	0.253
1777	0.005	0.010	0.247	1.168	0.146
1778	0.005	0.007	0.195	1.195	0.207
1779	0.006	0.007	0.247	1.183	0.174
1780	0.007	0.008	0.221	1.062	0.150
1781	0.003	0.008	0.247	1.125	0.186
1782	0.004	0.006	0.200	1.122	0.156
1783	0.008	0.012	0.260	1.266	0.295
1784	0.005	0.007	0.195	1.228	0.205
1785	0.004	0.007	0.260	1.145	0.197
1786	0.009	0.007	0.286	1.130	0.239
1787	0.007	0.007	0.260	1.150	0.184
1788	0.008	0.007	0.247	1.150	0.246
1789	0.005	0.011	0.273	1.110	0.199
1790	0.006	0.005	0.260	1.183	0.176

*Charge 1730 is high-speed tool steel and contains 4.83 per cent chrome and 20.79 per cent tungsten.

consumers of staple products of steel, for a better and more uniform quality, I have also come across many manufacturers requiring a large tonnage of steel forgings and steel castings, who are unanimous in their demands for a supply of a better and more uniform product.

It is a well-known fact that the steel casting industry has made no progress of late years. I am told, on good authority, that there is a wastage of about 50 per cent in medium and light-weight castings, particularly in castings of odd shapes. This is principally due to impurities and sluggishness of the metal in casting.

With less than one-third of the power necessary for purification and refining, the liquid metal can be held indefinitely in the Heroult electric furnace, without any loss in its composition, and a highly liquid metal, can be cast uniformly, free from impurities and gases.

It is my belief that the enormous waste now suffered in steel foundries above mentioned, could be practically overcome, and that castings of greater strength and better and more uniform quality, could be produced.

In addition to this, a large tonnage of forgings could be substituted by castings, which would give additional work to steel foundries and save a lot of work and expense to manufacturers, who are obliged to use forgings on account of the difficulty to obtain satisfactory steel castings.

Notwithstanding the fact that steel forging and steel casting makers are obliged to scrap a large percentage of their product before shipping same, in trying to meet the requirements of purchasers, the latter are subject to a great loss in rejecting forgings and castings, due to serious defects discovered in the process of finishing the same.

There is undoubtedly a large market for a better quality of these products, and for a sounder and more homogeneous article. To produce these by the old, reliable crucible process is prohibitory on account of excessive cost. Aside from this it is not convenient and practical to produce anything but light-weight forgings and castings by this process.

The Héroult process overcomes all these obstacles and eliminates every objection. With comparatively little additional cost the hot metal may be taken from the Bessemer or open-hearth furnace and be thoroughly purified and refined in our electric furnace.

The whole situation centers in the cost of electric power. Now, the modern large gas engine operated with waste gases from blast furnaces or with producer gas from cheap fuel has made it possible to generate electric power at a very much reduced cost compared with steam power. Yet the great majority of our industrial plants, steel works included, which have been otherwise progressive, are still continuing to obtain their power by means of obsolete steam engines.

They will soon be forced, for economical reasons, to keep pace with progressive Germany, where steam power has been replaced by gas engines of large, small and medium units to an enormous extent. A few very large and progressive steel plants in this country are proceeding in this direction and show the others the way they will have to follow.

Figures don't lie. The intelligent steel maker, if he takes the trouble to do so, can readily convince himself that electric power can be generated by modern gas engines at a surprisingly low figure as compared with former cost.

The power being the principal item, or practically the only one in the cost of electric steel making and refining, it will be a question of a comparatively short time after introduction of gas power when all Bessemer converters and open-hearth steel furnaces and even cupolas will be provided with electric furnaces as auxiliaries.

The progressive makers that will bring then a superior product on the market first will force the rest to follow suit.

The twentieth century has begun with a new chapter in the steel industry, and its head-line is electricity.

New York City. R. H. Wolff.

Albany Meeting of the American Electrochemical Society

The thirteenth general meeting of the American Electrochemical Society, held at Albany, Schenectady and Troy, on Thursday, Friday and Saturday, April 30, May 1 and 2, was very successful. There was a satisfactory attendance throughout the meeting, and all the members of the local committee did their utmost to make the visitors feel at home.

The meeting was exceedingly enjoyable in all its features, though it was a slightly strenuous affair with three sessions devoted to the reading and discussion of papers on Thursday (even without the extra sessions of Section Q), with morning sessions on Friday and Saturday, and with the fulness of the program with respect to visits and excursions.

EDWARD G. ACHESON, PRESIDENT OF AMERICAN ELECTROCHEMICAL SOCIETY.

The annual business meeting, held at the beginning of the afternoon session of Thursday, showed the society to be in a satisfactory condition. The number of members is now 715, and there is a fairly steady increase of about 10 per cent. in the membership per year.

The election of officers for the coming year was announced as follows: Mr. E. G. Acheson, of Niagara Falls, is the new president, while Dr. J. W. Richards and Mr. P. G. Salom were re-elected as secretary and treasurer, respectively. Dr. C. A. Doremus, Mr. C. P. Townsend and Dr. W. R. Whitney were elected vice-presidents for two years, in addition to three vice-presidents whose term did not expire. Mr. F. A. J. FitzGerald, Mr. Alois von Isakovics and Prof. S. A. Tucker were elected managers for three years, in addition to six other managers whose terms did not expire.

The Pacific Coast Borax Company offers a prize of $500 for a process of making ferroboron from commercial borate of lime, the prize to be awarded by the board of directors of the society.

Dr. A. T. Lincoln, of the University of Illinois, suggested the creation of associate membership for students. The proposal was referred to the board of directors.

The three sessions of Thursday were held in the ballroom of the Hotel Ten Eyck, in Albany; the session of Friday morning in Union University, Schenectady, and the session of Saturday morning in the Rensselaer Polytechnic Institute in Troy.

After the Friday morning session, lunch was tendered to the society by the General Electric Company, followed by an inspection of the works, which took up the whole afternoon.

The importance of these world-renowned works is so generally recognized that nothing need be said here in this respect. Some very large transformers in course of construction and the beautiful immense Curtis steam turbine hall attracted well-deserved attention and admiration.

To the chemical engineers in the party many of the apparatus and processes in use by the General Electric Company in various departments were of special interest, like the drying and impregnating apparatus in the wire and cable department, the lead-covering machines, the gas annealing furnaces and forges of the Rockwell Engineering Company; further in the insulation department ball mills of the Abbe Engineering Company, pug mills, mixing machinery for preparing the clay, molding machinery, etc. For the heat treatment of insulators gas furnaces are employed for the lower temperatures, while an interesting electric furnace with automatic feeding and discharging arrangement is used for the higher temperatures. The gradual development of mica insulation plates from crude mica is quite interesting.

The electric furnace house contains experimental furnaces of fair size of all the familiar commercial types.

In the evening of Friday an informal dinner united the whole party in the Ten Eyck in Albany.

After the Saturday morning session lunch was taken at the Rensselaer Inn in Troy, while the afternoon was devoted to various excursions and visits. Among the places visited were the Watervliet Arsenal, the Earl & Wilson linen factories, the Burden Iron Works, and W. & L. E. Gurley's factory of engineering and surveyors' instruments, transits, levels, physical apparatus, thermometers, etc.

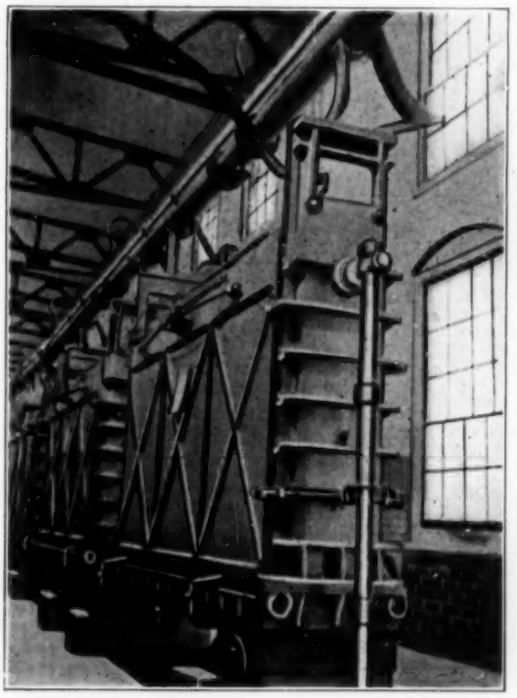

FIG. 1.—EXTERIOR OF HARGREAVES-BIRD CELL.

Quite a large party made an excursion to the Duncan paper mill of the West Virginia Pulp & Paper Company, at Mechanicville, N. Y., with its new electrolytic chlorine plant as chief attraction.

The well-known Hargreaves-Bird diaphragm cell is there in use, and the well-arranged and well-managed installation was generally admired. Water power is utilized to generate the current for the electrolytic works, there being two 390-kw, 126-volt, 3095-ampere Westinghouse generators, running at 150 r.p.m. There is spare room for four more generators.

In case of lack of water or of an accident, power can be had from the main steam-turbine-driven power plant of the works, where 2000 kw in alternating current and 800 kw in direct current are available. To produce the current for electrolysis, a motor-generator is provided, consisting of a 450-hp, 500-volt, 750-ampere motor and a 300-kw, 100-volt, 3000-ampere generator, running at 450 r.p.m.

Figs. 1, 2 and 3 show some details of the electrolytic chlorine plant. The cell room contains a series of rows of cells, each two rows being connected in series. Since each row contains 14 cells, 28 cells are connected in series across the 126-volt

mains. One corner of the very clean cell room is illustrated in Fig. 1, which shows clearly the exterior of the Hargreaves-Bird cell.

Fig. 2 shows the absorption towers in the background and the settling tanks for the bleaching liquor in the front. Fig. 3 shows the construction of the anodes.

The inspection of these works, through which the visitors were led with great courtesy by officers of the company, was greatly enjoyed.

In connection with the professional sessions devoted to the reading and discussion of papers, several interesting exhibits had been arranged. Mr. Max Meyer, of the New York

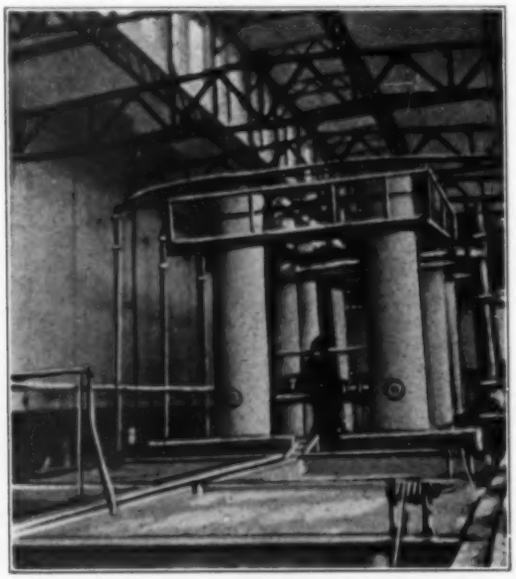

FIG. 2.—ABSORPTION TOWERS AND SETTLING TANKS.

branch of Voigtländer & Sohn, exhibited several of their well-known microscopes, while Mr. Foster, of the Taylor Instrument Company, of Rochester, exhibited several types of pyrometers of the well-known construction of the Cambridge Scientific Instrument Company, which will hereafter be made by the Taylor Instrument Company in this country.

In the following we give a complete account of all the papers presented at this meeting.

* * *

Resistances of the Order of One Hundred Thousand Megohms.

The first paper was presented by Dr. Howard L. Bronson, of McGill University, Montreal, on the construction and accurate measurement of resistances of the order of 100,000 megohms. An instantaneous measurement of very small currents is of great importance for researches on the passage of electricity through gases and on radioactivity. The best method is probably the "constant deflection method" of Rutherford, but it requires the use of permanent high resistances of the order of 10^{11} ohms.

While it is possible to get resistances as large as 10^{11} ohms by means of fine carbon lines on ebonite or ground glass, or by means of amyl alcohol or xylol in long capillary tubes, such resistors always show considerable variation and uncertainty. The carbon line seems to have practically its entire resistance at one point and to be merely a case of bad contact, which is bound to be very uncertain and subject to all kinds of external conditions. The liquid resistances have very large temperature coefficients, and seem to be subject to a variable polarization. In both classes of resistances, there is necessarily present a considerable amount of insulating or dielectric material. The absorption due to this is a function both of the time and temperature.

These difficulties were overcome by making use of the resistance of an ionic gas on the basis of the law that the ionization current, through a gas subject to a constant source of ionization, is approximately proportional to the potential difference between the plates when this potential is small.

The author constructed resistor vessels of ebonite of inside dimensions of 2.5 by 1.5 cm, with electrodes of aluminium, the active material consisting of about a tenth of a milligram of radium bromide. It is generally possible to so adjust the distance between the plates that a linear relation will exist for a considerable range of potential. Nevertheless, it is necessary to get a calibration curve for every such vessel, and it is recommended to use a double method of calibration.

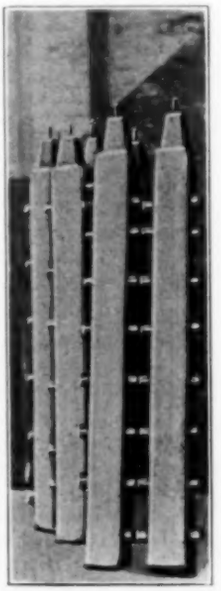

FIG. 3.—ANODES.

The results given in this paper would suggest the possibility of making of standard vessels of this type and preserving them as permanent high-resistor standards. They would have a much higher resistance than any of the usual standards and ought to remain constant over a long period. They would be found very useful for insulation testing or any very high resistance measurements.

In the discussion which followed and in which Messrs. Bancroft, Hering and Wolff participated, it was suggested by Mr. Hering that the Brownian movements of colloidal particles might be made use of for measuring very small currents, since the application of the smallest electric field causes the particles to move in a certain direction. In reply to a question of Dr. Bancroft, Dr. Bronson stated that the gas in the vessel does not appear to affect the results.

* * *

Absorption of Radioactive Emanations.

A paper on this subject was presented by Dr. R. W. Boyle, of McGill University. Dewar has studied in detail the absorption of ordinary gases by charcoal and has found absorption to occur to a very considerable degree at low temperatures. In order to find how far the similarity goes between radioactive emanations and ordinary gases it was of interest to study the observation of radioactive emanations by charcoal with varying temperature.

Different kinds of charcoal were tested and it was found that cocoanut charcoal is the most suitable for absorption tests. The absorption was determined as a function of the temperature, most experiments being made with thorium emanation. The absorption was determined between the temperature of solid dioxide and about 210° C., which is the approximate temperature at which charcoal begins to oxidize. The analogy between radioactive emanations and ordinary gases with respect to absorption by cocoanut charcoal appears to be complete. As a matter of fact, in everything else except in decay, radioactive emanations behave just like ordinary gases.

* * *

Temperature Coefficient of Weston Cell.

Dr. Frank A. Wolff, of the Bureau of Standards, gave a preliminary report on some measurements of the temperature coefficient of the e.m.f. of the Weston cell between 0 and 40 deg. C. Measurements were made for every five degrees, and in each case a complete cycle was carried out, passing, for

instance, from 5 deg. C. down to 0 deg., maintaining the cell at this temperature for about two days and then returning to 5 deg. One of the important results of these tests is that some cells exhibited very considerable hysteresis, especially those with abnormal initial values and also cells which were normal initially, but subsequently developed irregularities.

Dr. Wolff gave the following new approximate formula for the change of the e.m.f. e_t of the Weston cell at the temperature t degrees C. in volts with varying temperature:

$$e_t = e_{20} - 0.000040\ (t-20) - 0.0000009\ (t-20)^2 + 0.00000009\ (t-20)^3$$

It was found necessary to use a third term in this equation, while the usual (Reichsanstalt) formula contains only two terms. According to the above formula the e.m.f. has a maximum within the region between 0 and 5 deg. C., while there is no such maximum according to the Reichsanstalt formula. It is interesting to note that the maximum solubility of cadmium sulphate lies within the same region of temperature and that the portable cells of the Weston type are saturated at the same temperature.

The paper was discussed by Messrs. Carhart, Hering and Lidbury. In reply to a question by Professor Carhart, Dr. Wolff stated that in the temperature cycle to which the cells were subjected, those which showed hysteresis showed greater deviations from the normal values in the falling branch of the temperature cycle than in the rising branch.

Dr. Carhart expressed the opinion that hysteresis is due to the size of the cadmium sulphate particles and to delay of diffusion. According to Dr. Carhart, mercurous sulphate when chemically precipitated gives better results than when electrolytically prepared. On the other hand, Dr. Wolff stated that the size of the grains of the cadmium sulphate appears not to have any effect, and that the cause of hysteresis must be found in the paste limb. Further, according to Dr. Wolff, it does not matter whether the mercurous sulphate is electrolytically or chemically prepared; no real difference was found when the mercurous sulphate was made by six or seven different methods.

Mercury Cathodes in Nitric Acid.

A paper by Mr. J. W. WILKINSON, of Cornell University, on this subject, was presented in abstract by Prof. W. D. Bancroft.

Tafel has given some years ago an example which appeared to show a distinct difference between chemical and electrochemical action. When copper dissolves chemically in nitric acid, the latter is reduced to N O. On the other hand if nitric acid is electrolyzed with a copper cathode, ammonia is set free at the cathode. Similarly we obtain hydroxylamine by electrochemical reduction of nitric acid at a mercury cathode and again N O by chemical reduction with mercury. Thus chemically we get N O both with copper and mercury, electrochemically we get other reduction products and different from each other.

J. W. Turrentine has already dealt with the case of the copper cathode (*Transact. Am. Electrochem. Soc.* Vol. X, p 49) and shown that if the chemical and electrochemical reactions are carried out under exactly the same conditions, the products are the same. The chief point is whether there is copper present as ion in solution. If so, the chief product of electrolysis is N O, just as in chemical reduction. The present paper by Wilkinson deals with the case of the mercury cathode in exactly the same way and shows that the conditions are here exactly analogous. If we have mercury in solution we get the same products chemically and electrochemically. This is another proof of the general rule of Dr. Bancroft that chemical and electrochemical reactions yield exactly the same products, if only both reactions are carried out under exactly the same conditions. The paper was briefly discussed by Dr. Patten.

PHOTOGRAPH TAKEN AT SCHENECTADY.

* * *

Joseph Henry in Albany.

Mr. JAMES F. MCELROY gave an account of the early work of Joseph Henry in Albany. Contrary to published statements, the birthday of Joseph Henry was Dec. 17, 1797. In 1826 he became instructor in mathematics in the Boys' Academy, the building still being located within the Academy Park, near the

Albany Capitol. On April 6, 1829, he described before the Albany Academy the construction of his new electromagnet which was immensely more powerful than any electromagnets formerly designed. Formerly bare wire was used for the windings and, of course, only one single layer could be used. Henry employed cotton covered wire ("cotton insulation, well waxed") and was thus enabled to use several layers of wire. Henry also clearly understood and explained the difference between series and parallel connection of cells.

In the Boys' Academy in Albany Henry installed the first electric signal transmission system over a wire of more than a thousand feet long. This was called by Mr. McElroy the first electromagnetic telegraph ever constructed.

In the spring of 1831 Henry discovered that a galvanometer, which he had in series with his electromagnet winding, showed a momentary deflection when the armature was suddenly pulled away from the electromagnet. This was before Faraday's fundamental discovery of electromagnetic induction in the autumn of the same year. Henry left Albany in 1832 to become professor at Princeton and later director of the Smithsonian Institute in Washington.

In the discussion which followed, Prof. Carhart referred to the signal transmission system installed by Henry. He emphasized that this was not only the first electromagnetic telegraph, but should rather be considered as the first electric power transmission on record. Henry clearly understood the importance of high voltage for power transmission as is shown by his emphasizing the advantages of connecting the cells in series. When the name Henry was selected for the unit of inductance at the International Electrical Congress in Chicago, 1893, Mascart, a Frenchman, proposed the name of Henry; it was seconded by an English delegate. Two definitions of the unit henry were proposed by a committee appointed for this purpose, but neither definition was found satisfactory. Then Ferraris, the distinguished Italian physicist, although not able to speak English fluently, proposed, within two minutes, the definition which found general approval and which was definitely adopted.

* * *

Fundamental Units of Electricity.

The society has received a request from Director Stratton, of the Bureau of Standards, to appoint a committee on units and standards which should co-operate with corresponding committees of the American Institute of Electrical Engineers and of the American Physical Society. It is the purpose of the Bureau of Standards to have American opinion crystallized in regard to the questions to be taken up by the next International Congress on electrical units. The committee appointed by the society in compliance with this request consists of Mr. Carl Hering, chairman; Dr. Theodore W. Richards, of Harvard; Dr. H. T. Barnes, of McGill, and Dr. Edward Weston.

In connection with these proceedings, a paper was presented by Dr. Frank A. Wolff, of the Bureau of Standards, in which the present situation of international fundamental units of electricity was concisely reviewed.

An informal international conference, called by the German Reichsanstalt, was held in October, 1905, and decided on three things: first, that there should be only two fundamental units; second, that the international ohm and the international ampere should be these two units; third, that the international volt should be defined by the ohm and the ampere. The conference rejected the recommendations of the Bureau of Standards and of Prof. Carhart, who advocated the adoption of the standard cell instead of the coulometer for the definition of the second fundamental unit. As to the necessity of having only two fundamental units, there was and is general agreement.

But the above action of the conference can only be considered as preliminary, since the conference had not yet seen fit to draw up the necessary specifications, as was pointed out by Dr. Wolff. It will be the duty of the next international congress to adopt definitely the two fundamental units and to formulate the specifications and agree upon the values to be used in the definitions.

Since all agree that the ohm should be one fundamental unit, the chief question is, whether the ampere or the volt should be the second fundamental unit. Three points are to be taken into consideration.

First, accuracy of reproduction. (*a*) As to the fundamental principle involved, the definition of the ampere is based on Faraday's law. But, while this law may be considered as absolutely true, the weight of the silver deposit may not agree exactly with the law on account of secondary reactions. On the other hand, the definition of the volt is based on an equally fundamental principle, though it has no generally accepted name; this principle states that the decrease of energy of a reversible galvanic battery in watt-hours equals the coulombs given out by the battery, multiplied by $e - T\frac{de}{dT}$ where e is the e.m.f. in volts and T the absolute temperature (Gibbs-Helmholtz equation). With respect to the fundamental character of the principle on which the units ampere and volt are based, there is no preference of one unit over the other. (*b*) As to the purity of the materials to be employed in the reproduction of the units, this point may be neglected, since the materials can be supplied by the national bureaus or laboratories. (*c*) As to the number of measurements required, the coulometer is at a great disadvantage compared with the standard cell. The cell automatically takes up its value.

Concreteness is the *second* point to be considered. There is no such thing in a silver coulometer. When a measurement has been made, there is nothing left but a silver deposit which is of no use for further measurements. The cell, on the other hand, is always ready for further measurements.

Ease of reproducibility is the *third* important factor and here the standard cell is again at a great advantage.

If the attribute of constancy of the standard cell would be established, then taking this together with its reproducibility, the volt seems even better than the ohm as to suitability for a fundamental unit.

While the German law legalizes the ohm and the ampere, yet the Germans have used a particular value for the e.m.f. of the standard cell since 1898, and the result is equivalent to legalizing that value in the first place.

While the accuracy of reproduction by different investigators has been satisfactorily established in the case of the cell, this has not been done in the case of the coulometer, for which only relative accuracy of reproducibility has been determined.

Although in the light of the present evidence, the adoption of the standard cell may be favored, yet the Bureau of Standards, in Washington, advocates a systematic international co-operation looking toward establishing the accuracy of reproduction of both the cell and the coulometer.

* * *

Corrosion of Iron.

The retiring president, Prof. Charles F. Burgess, of the University of Wisconsin, then presented his presidential address dealing with "the corrosion of iron from the electrochemical standpoint." The design of iron and steel structures has reached a high degree of development, but we know very little concerning the life of completed steel structures, we have no exact figures on their rate of decay and on their depreciation. This may vary much with local conditions. It may be as low as 1 per cent and as high as 20 per cent per year.

The corrosion of iron has been studied as an electrochemical phenomenon by Whitney and recently in greater detail by Walker and Cushman (our Vol. V, pp. 254, 257, 270, 343, 363). Iron corrodes when anode. All agree on this, but it seems wrong to assume that iron cannot corrode when made cathode. Prof. Burgess said that laboratory experiments had shown that under certain conditions iron may corrode when it is the

cathode. A possible explanation of this peculiar fact may be that under certain conditions a surface film may be present on the iron which protects the iron. When it is then made cathode, the surface film breaks down and the iron surface is laid bare and rendered liable to corrosion. This tentative explanation is analogous to the breaking down of the protective oxide film on an aluminium surface when used as cathode.

Electrolytic corrosion may be due to currents from an external source. The most important case of practice is the corrosion of underground water and gas pipes by the stray currents of electric railways, using the rails for the return circuit. The return current does not remain in the rails, but enters into the earth, and where it finds an iron or steel pipe it will enter the same. Whenever the stray current then leaves the iron into the surrounding ground, the iron is the anode and will be corroded. Methods have been found to mitigate this trouble, but it has not been completely solved. In theoretical respect many things are still unknown. For instance, we do not know whether Faraday's law holds strictly good for the earth or, in other words, whether the earth is a perfect electrolyte or whether the earth perhaps does act like a metallic conductor for small currents.

It is, however, not necessary that current from an external source be present to produce electrolytic corrosion of iron. Iron in contact with other metals (like copper) and moisture forms a galvanic couple itself, and an electric current will result, passing from the iron to the moisture and from there into the other metal and then back to the iron, thus flowing in a circle as required, without any external source of current. The more electronegative the other material, the more pronounced is the phenomenon. Carbon in contact with iron and sulphur in contact with iron represent such galvanic couples.

An observation of the effect of deflocculated graphite on the prevention of corrosion is apparently abnormal. Iron was rubbed in with Acheson deflocculated graphite and exposed to the atmosphere, together with other samples of iron. The iron treated with graphite did not corrode, while the other samples did. But when a heavy rainstorm came and washed the graphite off, the iron corroded just like the other samples. The action of the graphite is not yet fully understood; it may perhaps act simply like a paint.

From the above principle it follows that free carbon or sulphur particles in the surface of iron will cause galvanic couples and produce corrosion. Non-uniformity of the composition of the surface is, therefore, of greatest importance, since it represents a tendency for beginning corrosion.

Several microphotographs of the surfaces of iron were shown, for instance of electrolytic iron and of pure Swedish iron. "Slag areas" in the latter may represent the first cause of corrosion, resulting in localized pitting. Prof. Burgess emphasized repeatedly that the microscope will be found a very useful instrument in studying the corrosion of surfaces.

A large part of Prof. Burgess' address dealt with the influence of mechanical strain on the corrosion of iron. This problem has been suggested by the old question what becomes of the energy stored in a wound-up spring, when it is subjected to corrosion. It seems possible that the energy stored in the spring might manifest itself in form of an e.m.f., or in general that mechanical strains might have an effect on the e.m.f of electrochemical corrosion. Various investigations have been made by Hambuechen, T. W. Richards, Walker and others, with greatly different results. Prof. Burgess reviewed the whole subject and thought there were sources of error in all. Prof. Burgess then gave an account of some experiments made by himself, the results of which were shown in very interesting lantern slides.

In one set of tests, steel bars were subjected to tension up to a point just before rupture. The tension was then released and the surfaces of the bars were ground down to a uniform diameter and polished. When subjected to corrosion it was found that those portions of the test bars which had been strained were corroded to a much greater degree than the rest. This effect was very clearly shown and unmistakable in the lantern slides. The corrosion tests were made either by simple chemical corrosion without current in a hydrochloric acid solution or with current in a neutral solution, using the test bar as anode.

In a similar way torsion strains were applied to the middle portions of test bars. After the strain had been released the test bars were subjected to pure chemical corrosion. The electrochemical nature of the corrosion (although no external current was employed in these tests) became manifest, from the fact that the upper and lower parts of the test bars (which had not been strained) became densely covered with gas bubbles, while the strained central part remained bright, there being sharp lines of demarcation between the parts where gas bubbles appeared and where not. The explanation is that the gas bubbles appear at the cathodes, while the part free from gas bubbles acts as anode and it is this part which corrodes. These lantern slides proved manifestly the greater tendency of strained iron to go into solution.

The punching of boiler plates is also interesting in this respect. The usual specification is that boiler plates should be drilled. Punching weakens the metal, sets up strains in it and subjects it to greater subsequent corrosion. This was also shown by lantern slides of a corroded punched piece of boiler plate, showing the greatest corrosion close to the hole, where the strain had been a maximum, and deep grooved lines running off from the hole into the surrounding metal. These rays of lines indicate strain lines and indicate weakness of the iron in these directions.

Strains produced in tempering steel also show up clearly in corrosion tests.

The final part of Prof. Burgess' address dealt with the effect of temperature differences on corrosion, with special reference to locomotive boiler tubes. It was shown that the pitting and grooving observed in practice is what should be expected theoretically. The effect of steam pressure was also investigated. An interesting result found was that air dissolved in the water appears to be detrimental. It seems that the oxygen of the air acts as depolarizer at the cathode in agreement with Dr. Walker's theory. On the other hand, the presence of carbon dioxide in boiler water is not a disadvantage.

The interesting address of Prof. Burgess elicited quite an extended discussion. Mr. E. G. Acheson spoke on the production of steel by means of deflocculated graphite. A piece of bright steel immersed in water containing deflocculated graphite does not rust, while it rusts in other ordinary water. But immersing a piece of steel once or repeatedly in water containing deflocculated graphite does not produce a permanent cure against corrosion. Nevertheless, for the protection of special pieces of machinery, experience seems to show that rubbing graphite into the surface is valuable.

Other speakers participating in the discussion were Messrs. McElroy, Wolff, Lidbury, Sharp, Grower, Hering and Bancroft. The latter emphasized that not only the e.m.f. of galvanic couples set up at the surfaces of iron and steel structures should be considered, but also the possibility of surface films. The latter may stop the current, due to its insulating properties. The existence of an e.m.f. due to a galvanic couple indicates only the first initial tendency of the surface to corrosion.

Prof. Carhart referred to two suits now pending as to the liabilities of tramway companies for alleged damage done to water and gas pipes by stray currents. It is by no means easy to trace in a special case the damage to the original causes. It is a suggestive fact that vertical poles or columns are also subject to corrosion. The thermoelectric effect should not be overlooked in such investigations. A communicated discussion by Dr. T. W. Richards pointed out that electrodes which are not in equilibrium do not give constant results.

Corrosion of Rochester Steel Conduit.

Mr. R. H. Gaines presented a paper on this subject giving details of a concrete instance of rather disastrous corrosion. The Rochester steel conduit was laid in 1893 or 1894. The part which developed corrosion later on was coated with asphalt. There developed in the whole 164 rust leaks.

Soon after the first leaks developed, the conduit was examined and wherever there was an indication of something wrong an anti-corrosive paint was applied. It was thought that had not this been done far more leaks would have developed.

Mr. Gaines examined the conduit in June, 1907, in behalf of the New York Water Supply, which plans a large aqueduct for which steel pipes may be used. The inspection of the conduit in 1907 showed that about four-fifths of it was still in good condition, while in one-fifth corrosion was active, partly in its first stages, but partly had progressed further.

The pits which had developed were mostly round, although some were longitudinal. When the rust was taken out a round hole was found. The thickness of the pipe is 5/16 in. Many of the holes look just like pin holes.

Almost the complete corrosion appeared to be from the outside, while the pipe was hardly corroded from the inside. It seems that continuous contact with water is not nearly as detrimental as intermittent supply and withdrawal of the water; of course, the salts outside in the soil had also great effect. It was first suspected that electric stray currents from outside sources were at the bottom of the trouble, but it was not possible to detect any.

Mr. Gaines concludes that no single cause can be offered as a satisfactory explanation. This case of corrosion seems to be the result of a combination of physical conditions. First, there was an inadequate protection of the pipe. Secondly, the influence of the soil containing chlorides of magnesium, calcium, etc. (nearly one per cent soluble salts), with an excess of water, is undoubtedly of great importance. Thirdly, we have the lack of homogeneity in the structure and composition of steel as a determining factor. The development of galvanic couples results in what Mr. Gaines calls "auto-electrolysis." Stray currents from an outside source may aggravate the trouble, but are not needed to produce electrolytic corrosion.

This paper also elicited a long discussion. Mr. Hering said that the fact that the milliammeter does not show a current is no proof that there are no stray currents. Mr. McElroy related a case in which stray currents had passed through a pipe whether it was perpendicular or parallel to the street railway line. Dr. Bancroft remarked that chlorides in contact with iron will, of course, cause rust, but the important thing in which iron and steel engineers should interest themselves is to find out exactly the lack of homogeneity in the structure and composition of commercial steel. Dr. Sharp referred to the self-deception of alleged experts in the use of the voltmeter in so-called "electrolytic surveys." Serious as the situation of destruction of water pipes by stray currents is, some tests made by "experts" are ridiculous; they read an indication of the voltmeter, assume so and so many ohms in the earth and conclude that there is a current flowing of so many hundred thousand amperes. Dr. Potter emphasized that the electrolyte should be eliminated by using an impervious non-conducting coating on all underground pipes. Mr. Gaines gave in his reply a number of analyses made in his investigation.

* * *

Industrial Applications of Aluminium.

Mr. E. Blough, of the Aluminum Company of America, presented a paper dealing purely with the commercial aspects of aluminium. An interesting exhibit shown by him was a sample of aluminium made by Mr. Charles M. Hall in 1886 with current from a galvanic battery.

In its early history the aluminium industry was hampered by the extravagant untrue claims of the general press. But the industry long ago reached a sound condition by pushing the use of aluminium only for those purposes for which it is specially well adapted. Aluminium is applied either alloyed or pure. Alloys are chiefly used for castings. Practically all aluminium castings are made from alloys and are used for many purposes. Among the great number mentioned by the author there were electric meter frames, meter covers, pipe fittings for aluminium tubing, etc.

Aluminium has now become quite an important element in steel manufacture, being used as a deoxidizing agent to produce sound castings. While only very little is used in each case many thousands of pounds per year are employed for this purpose.

Aluminium sheet metal may be had hard or soft. It is rolled in all gauges from the very thickest to the very thinnest. It is used for automobile bodies, for signs, for cooking utensils, etc. In the New York Subway some of the cars are lined with aluminium. In a large number of Eastman kodaks it is also employed.

Aluminium tubes are made in all sizes and shapes. The thinnest pipes are used as indicating instruments for needles.

Aluminium is finding now a steadily increasing market in the chemical industries, as in acetic acid plants, for nitric acid condensers, ammonia concentrators, further in pulp mills, etc.

Copper pipe is now made lined with aluminium for use in surface steel condensers.

Aluminium rods are made in all shapes for various uses. In electric power stations aluminium busbars are employed, while for high-tension transmission lines the use of aluminium wire is steadily increasing in importance, especally in the West. Street and interurban railway companies also use it. "Bimetallic wire" is now being introduced for various purposes, being a steel wire coated with aluminium.

An interesting exhibit showed the development of an aluminium coffee pot in the various steps of manufacture from the plain aluminium sheet which is brought into the proper form by drawing and spinning. The Japanese army was fully equipped during the last war with aluminium mess kettles, which proved very satisfactory.

* * *

Copper Anodes in Chloride Solutions.

Mr. Saul Dushman presented an account of a very elaborate experimental investigation. When copper is used as anode in hydrochloric acid it passes into solution both as cuprous and cupric salt, and according to the variation of the conditions of the experiment (variation of the current density, concentration, etc.) either the cupric or the cuprous salt will prevail.

Mr. Dushman explained that at the surface of the anode there is a chemical equilibrium between the cupric and cuprous ions and the metallic copper in contact with the electrolyte. There are two equilibria, indicated by the equations:

$$Cu^{\cdot\cdot} + Cu = 2Cu^{\cdot}$$

and in presence of chlorine

$$Cu^{\cdot} + 2Cl' = CuCl_2'$$

The determination of the equilibrium constants of these two reversible reactions form the first part of the investigation.

The second part of the investigation relates to the experimental determination of the change of concentration at the electrode by means of a very elaborate special arrangement. It was thus found possible to calculate the concentration exactly at the anode.

* * *

Electrochemistry of Light.

The session of Monday evening was chiefly taken up by an experimental lecture of Prof. Wilder D. Bancroft, of Cornell

University, on the electrochemistry of light, proposing an electrolytic theory of photochemical phenomena.

While in some cases the effect of light on chemical processes is due to a simple heating effect of the light, this explanation does not cover those processes properly called photochemical. In the latter light energy is transformed directly into chemical energy. Grotthuss, in 1818, formulated the first two laws of photochemistry. The first law, which appears to be universally accepted, is that only light of those wave lengths which are absorbed by the chemical system can (not necessarily will) produce a photochemical effect. The second law is that the action of light can be considered as analogous to a "linear voltaic cell." While this is not very clear, the following quotations from Grotthuss will indicate his meaning.

"Light separates the constituents of many ponderable compounds and forces them to form new compounds with its own imponderable elements +E and —E, just as the portions of the voltaic battery do to a still greater extent." (In our present terminology we would probably express the same idea by saying that light ionizes the compounds into ions carrying opposite electric charges.) According to Grotthuss, "a ray of light is a line along which the elements of neutral electricity arrange themselves into polar fashion." (This suggests at once the familiar mental picture of the Grotthuss ionic chain extending from anode to cathode in an electrolytic cell.) Grotthuss suggests, therefore, that there is a general analogy or parallelism between photochemical and electrochemical phenomena. The object of Dr. Bancroft's paper is to emphasize the very great value of this fundamental conception, namely, that the chemical action of light is essentially electrolytic in nature.

Dr. Bancroft gave an immense amount of special facts illustrating Grotthuss' principle. But in this abstract it is possible to refer to a few typical examples only. (A very full account of the subject covered in the first part of Dr. Bancroft's lecture may be found in a paper of Dr. Bancroft in the April issue of the *Journal of Physical Chemistry*.)

Practically all the salts of silver are decomposed by light under some circumstances, the final product being either silver or some other reduction product. The decomposition products are the same as those obtained by electrolysis. Ferric chloride, sulphate, oxalate, tartrate, citrate and sulphocyanate are decomposed by light under suitable circumstances with formation of the ferrous salt, just as would happen if the solution were electrolyzed. The double ferric oxalates and the ferricyanides are reduced by light and by electrolysis. In presence of a suitable oxidizing agent such as oxygen, ferrous sulphate or sulphocyanate is oxidized to the ferric salt. It is a matter of common knowledge that ferrous salts can be oxidized electrolytically.

The example of the action of light on ferrous sulphocyanate is of historical interest since it was studied by Grotthuss with remarkable experimental skill. In experiments on the behavior of ferric sulphocyanate dissolved in alcohol, Grotthuss found that when air was kept away from the solution, sunlight caused the red color to disappear. If the solution were placed in an unstoppered flask and exposed to the light, it was decolorized in the morning, reddened at noon, and decolorized again in the afternoon. Grotthuss set himself to the task of accounting for this difference in the action of the sun's rays at different hours of the day.

He soon established that difference in the heat of the sunlight at morning or at noon had nothing to do with the reaction, but that the whole phenomenon was due to the fact that in the morning and evening hours the rays of light are nearly parallel to the surface of the liquid and therefore pass directly into the solution from a non-oxidizing medium, the glass walls of the flask in which the tincture is contained. On the other hand the rays at the noon hours are more nearly perpendicular and pass into the solution from an oxidizing medium, the oxygen of the air. The reddening occurs only when the rays of light pass through the contact surface between air and solution. This was clearly shown by sending rays through the solution in different directions by means of system of mirrors.

Dr. Bancroft then considered what the fundamental conditions are which make it possible for light to decompose the salt of a metal. If light according to Grotthuss is analogous to a linear voltaic cell, its e.m.f. is very low, probably rarely exceeding half a volt. To get a photochemical reaction it is, therefore, necessary to start with a salt having a low decomposition voltage or to add something to the solution which will lower the decomposition voltage. In other words, we must add a depolarizer.

For example, ferric chloride in water is practically non-sensitive to light. In alcoholic solution it is reduced by light to ferrous chloride. The reason for the difference is that chlorine reacts readily with alcohol, but not readily with water. On the other hand, Grotthuss found that ferric sulphate in alcohol was only acted on very slowly by light. The reason for this is that alcohol is not a good depolarizer for oxygen, but is a good one for chlorine.

The light-sensitiveness of all substances is increased by the presence of a suitable depolarizer, and, in many cases, we get light-sensitiveness only in presence of depolarizers.

An interesting case of a depolarizer is silver nitrate and silver iodide. The silver nitrate can react with an iodide and consequently make silver iodide more sensitive to light.

Further, the presence of the depolarizer and its nature really determine what the photochemical action will be. Whether a given substance is to be reduced or oxidized by light, depends on the nature of the depolarizer entering into the reaction. If the substance we are considering is in presence of a strong enough reducing agent, it will be reduced by light. If it is in presence of a strong enough oxidizing agent, it will be oxidized by light.

When light is absorbed by mercurous chloride, the mercurous chloride tends to disappear; but there is nothing in the action of the light *per se* to determine whether the mercurous salt shall be reduced to mercury or shall be oxidized to a mercuric salt. Either change involves the elimination of the mercurous salt. In presence of ether, sunlight reduces mercurous chloride to mercury. In presence of an oxidizing agent, light changes mercurous chloride to mercuric salt. When no especial reducing agent is present, the mercurous chloride acts as its own depolarizer and we get a mixture of mercury and mercuric chloride. Light tends to set free chlorine from silver chloride and light causes silver and chlorine to react. In most cases of oxidation, the reaction takes place in presence of air and the oxidizing agent is oxygen.

In this way it was shown by Dr. Bancroft that photochemical reactions are generally analogous to electrochemical reactions, and that the results of photochemical reactions can be reproduced under corresponding conditions by electrolysis. An interesting illustration was the production of "electrolytic photographs," that is the production of pictures on blue print paper by electrolytic means.

The paper was discussed by Prof. Baskerville, Prof. Burgess and Dr. Baekeland. The latter spoke at some length on the great interest of photochemical research which should bring results of inestimable value. But the difficulties of this research are very great. If we want to imitate nature we have to do with exceedingly delicate reactions and have to employ nature's exceedingly delicate methods. Ordinary chemical analysis fails utterly in studying photochemical reactions. The most important photochemical reaction of nature is the observation of carbon dioxide from air by the chlorophyl of green plants. We know there is a magnificent system of regulation and a large surface for evaporation, etc., but we do not understand how the reaction goes on. As to the electrolytic photographs of Dr. Bancroft, he remarked that an accidental case of the production of such a cathode picture had once caused enormous trouble and expense to a photographic paper supply

company. Due to the presence of minute brass particles black spaces with a white ring around were produced on the sensitive paper which was thereby spoiled entirely. It was finally traced by Dr. Backeland directly to electrolytic action.

* * *

Forestry, Water Storage Power and Navigation.

The last paper of the evening session was presented by Mr. Edward R. Taylor, of Penn Yan, N. Y., on Forestry, Water Storage Power and Navigation. The author emphasized that the problems of preservation of our forest reserves, water storage and water power developments and navigation are all closely interconnected. They must be considered together from a broad point of view.

It is, for instance, a mistake to think that reforesting alone will solve the problem. While it may mitigate the disastrous floods occurring regularly in springtime and causing immense damage it will not prevent them. What is really needed, besides reforesting, is to build larger or smaller lakes in the upper country and impound the water so as to hold it back in time of flood and save the immense loss and damage, and at the same time produce highly valuable water powers and navigable rivers all through the dry summers.

This solution of the problem will be expensive, but it will more than pay the cost in the end. The water powers thus made available will be of very great value. The author thinks that the water power possibilities of the State of New York are more valuable than all the coal mines of Pennsylvania. It has been estimated by the N. Y. State Water Storage Commission that water power in New York State can be made to produce an annual profit of $18,000,000, which, equals, if it does not exceed, the net profits of agriculture in this State.

To get up the money needed, the State or the Nation could advance it for performing the work and the people who are saved, the floods will gladly pay the taxes to refund the State or Nation; further, there will be a large income from the users of water power. The lumber that must be cut to give place for lakes will give the Forestry Department money with which to reforest the districts now deforested.

If these interconnected problems are to be solved they must be approached from a broad point of view. Mr. Tayor called attention to the excellent work which is being done by the New York State Water Supply Commission and by the American Forestry Association.

* * *

Kinetic Molecular Energy.

The first paper presented at the Friday meeting in Union University, Schenectady, was a lecture by Dr. Charles Proteus Steinmetz, in which he showed that the familiar gas laws of thermodynamics can be derived from the conception of irregular molecular motion on the basis of the elementary principles of mechanics with the laws of probability.

The mental picture of irregular molecular motion is the foundation of the kinetic theory of gases. But while ordinary theory employs such artificial conceptions as collisions between perfectly elastic bodies, Dr. Steinmetz shows that there is no need for such assumptions. It is perfectly feasible to get all results by simply applying the laws of cosmic motion (sun, planets, comets) to molecular motion, without assuming any collisions.

The condition of molecular motion is chiefly determined by the velocity. According to the velocity of the molecules we have solids, liquids and gases. Within the lowest range of molecular velocity, the movement of the molecules is oscillatory; we have a fixed relative position; the body has a size or shape; it is a solid. Within the next higher range of molecular velocity, the velocity is able to carry the molecules just beyond the region of opposing forces; the molecules move in closed elliptic orbits (like the planets around the sun), the body loses its form and shape, but retains its volume; it is a liquid. When the molecular velocity is raised still further, the molecules move in open parabolic paths; the body not only has no shape or form, but actually tends to increase its volume; it is a gas.

On the basis of these conceptions it is now easy to define the temperature and pressure of a gas in such a way that these definitions will directly lead to the familiar gas laws. The temperature is defined as proportional to one-half molecular mass multiplied by the square of molecular velocity. The pressure is defined as proportional to the number of molecules per unit of volume multiplied by molecular mass multiplied by the square of molecular velocity. Both definitions are very plausible in the light of the conception of molecular composition of matter. Dr. Steinmetz showed how by starting from these definitions it is easy to get directly the Boyle-Mariotte-Gay-Lussac laws and Avogadro's rule as consequences of elementary mechanics of molecular motion and the laws of probability.

In the same way Dr. Steinmetz discussed the expansion of a gas while performing external work and showed how the molecular conceptions lead to the familiar result that the decrease of internal energy equals the external work done. He then developed the law for adiabatic changes; first for monatomic gases, and then passed over to a discussion of molecules consisting of several atoms.

This part of the lecture was perhaps the most interesting and original, since it differed in essential points from the orthodox methods of the kinetic gas theory. In discussing the case where a molecule consisting of several atoms comes into the sphere of action of another molecule, Dr. Steinmetz started again from a cosmic analogy, namely, the force which scatters the swarm of meteorites or disintegrates a comet when coming into the sphere of influence of a sun. When our diatomic molecule is acted upon by another molecule, there will result a couple of forces, a rotary motion within our diatomic molecule. There will be a redistribution of energy, energy being transformed from orbital molecular motion into intramolecular motion, i. e., the motion of the atoms in the molecule. This transformation of molecular into atomic motion is determined by the principles of probability and in this way the familiar formulas can be derived.

The further away we are from the boiling point and the higher in temperature, the nearer we are to "ideal gases." That is, theory always gives us the laws for ideal conditions. Such laws contain "constants," which are constant for ideal conditions, but which vary in real processes. To determine the variation of these "constants" must always be one of the chief objects of research.

Finally, Dr. Steinmetz showed how elementary molecular mechanics and the laws of probability necessarily lead to the result that heat always moves from higher to lower temperature—which result is perfectly familiar to everybody, but can hardly be understood or explained in any other way.

* * *

Latent Heat of Vaporization.

Dr. Joseph W. Richards, of Lehigh University, presented a paper on "the latent heat of vaporization." The metals, as far as they have been tested, pass into monatomic vapors, such as Na, K, Hg, Zn, and Cd, in which each atom represents a molecule. Trouton's rule, which is approximately correct for this case, states that the latent heat of vaporization of atomic weight is proportional to the absolute temperatures of the boiling point at atmospheric pressure, and is numerically equal to about 23 times that temperature, if the external work performed in overcoming the atmospheric pressure is included, or 21 times the absolute temperature of the boiling point if the external work is not included. From this rule we can estimate the amount of heat necessary to vaporize any metal the boiling point of which under atmospheric pressure is known.

Metallurgists, however, are often interested in the total heat

contained in the vapor when escaping under atmospheric pressure. This is 33 times the absolute temperature of the boiling point; it is the total heat required to raise the substance to the boiling point and boil it. This follows from the following approximate rules, which are often useful: If T is the temperature of the melting point and T^1 the temperature of the boiling point under atmospheric pressure, then the heat required to heat one molecule of the substance up to the melting point is 8T, the latent heat of melting is 2T, the heat raising the temperature from melting to boiling point is approximately 10 $(T^1 - T)$, the latent heat of boiling $23T^1$, hence total, by addition, $33T^1$; meaning in every case kilogram-calories per kilogram-molecule.

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Electrochemical Patents.

Mr. A. B. MARVIN, Jr., of the General Electric Company, presented a paper in which he sketched the development of patent laws and the history of the Patent Office of the United States. A patent is a contract between the inventor and the people of the United States. What the people pay to the inventor is the monopoly for a limited time. The Patent Office is a barometer of activity in certain directions; for instance, when there is a war many patents are applied for for war supplies; similarly patents for crude oil burners in times of coal strikes, etc.

Mr. Marvin exhibited curves showing a number of electrochemical patents taken out each year since 1860. One curve comprised all sub-classes of electrochemistry, since 1860. There are now being issued about 280 patents on electrochemical subjects per year.

A second curve referred to battery patents, beginning with 1880. The curve has two maxima, one in 1890 and the other in 1900 to 1902; the latter has to be connected with the iron-nickel battery.

A third curve showed electric furnace patents beginning with 1902. There are yearly granted about 42 such patents.

The author referred to the bad conditions now existing in the United States Patent Office, with its steadily increasing work, and with an overworked and underpaid staff absolutely insufficient in number. The Patent Office has a yearly surplus so that there should be no lack of funds, and the force should be greatly enlarged. The trouble is really with the inventors and manufacturers who are willing to stand the present conditions. It is their own business to look out for a prompter and better transaction of business at the Patent Office.

In the discussion which followed, Mr. Louis C. Raegener, of Dickerson, Brown & Raegener, emphasized that what is really needed is a reform of the patent laws of the United States. Our present law affords no protection whatever to the inventor. They are only for the benefit of the patent attorneys. Though in his 23 years of practice he has won many suits for his clients, he has never recovered a really good judgment which would have compensated the inventor for all his troubles. It is different in England. Moreover, under present conditions this country is practically divided into nine countries in so far as there are nine circuit courts and a decision in one has no effect on the others. Dr. Potter referred to Germany where patent protection is much better. German law gives actual protection to the patentee. Dr. Steinmetz said it would be important to protect the inventor rather than the patentee. Dr. Baekeland referred to the treatment which an inventor gets when he offers a patent to a large company; he is talked to in such a way that when he leaves the office he feels almost like a criminal. Mr. Marvin, in closing the discussion, said that the German Patent Office has a staff three times larger than our Patent Office and grants fewer patents. Naturally, the German patents are stronger.

* * *

Electric Testing of Iron During Annealing.

Mr. E. E. F. CREIGHTON described a method of studying the effect of temperature during annealing on the magnetic properties of iron. The sample to be tested was made the secondary of a transformer so that it was possible to simultaneously heat the iron by induction currents and test it for its magnetic properties. With increasing temperature the permeability decreases. The magnetism disappears at a temperature slightly less than 800° C. The temperature was then raised higher and afterwards brought back, and the magnetism was found to come back at exactly the same temperature where it had disappeared before.

The apparatus was used for testing the iron in the atmosphere of various gases so as to determine their influence on annealing practice. Tests in an ammonia atmosphere showed bad effects, which are probably due to the nitrogen, since hydrogen seems beneficial. It is possible that this explains the difference between Bessemer steel and open-hearth steel for electrical purposes. Steels of these two brands, which, according to chemical analysis, have the same composition, may differ in their electromagnetic properties and this difference may be due to the nitrogen blown through the molten metal. These tests were made in the works of the General Electric Company.

In the discussion which followed, Dr. Steinmetz remarked that electrolitically refined iron is extremely hard and has a very high hysteresis loss, which may be due to the content of nitrogen. Prof. Burgess confirmed that electrolytic iron refined with an ammonium salt solution, indeed, contains nitrogen. Dr. Richards referred to Braune's valuable investigations of the effects of nitrogen in iron (our vol. V. p 51).

* * *

Robert Hare's Electric Furnace.

A paper by Dr. CHARLES A. DOREMUS on Robert Hare's electric furnace was of great historical interest.

Robert Hare was formerly professor of chemistry at the University of Pennsylvania. Before the Chemical Society of Philadelphia (the first chemical organization of the world, founded in 1792) he announced in 1801, then but 20 years

FIG. 4.—HARE'S ELECTRIC FURNACE.

old, his discovery of the oxy-hydrogen blowpipe. The properties of "Drummond's limelight" were known to him.

Hare later turned to electric heating. In 1831 he used electric heating of a platinum wire for exploding the charges of gunpowder in rock blasting from a distance. This means was afterward employed in England in blowing up the wreck of the Royal George.

Hare's first electric furnace, which was a vacuum furnace, was described by himself in 1839 in a paper before the American Philosophical Society entitled "Description of an Apparatus for Deflagrating Carburets, Phosphurets or Cyanides, in Vacuo or in an Atmosphere of Hydrogen, with an account of some Results obtained by these and other means; especially the Isolation of Calcium."

The energy for operating the furnace was derived from a battery of primary cells consisting of copper and zinc plates in sulphuric acid solution constructed on the principle of a plunge battery. The furnace is shown in Fig. 4, and is described as follows:

Upon a hollow cylinder of brass (AA) an extra air-pump plate (BB) is supported. The cylinder is furnished with three valve cocks (DDD), and terminates at the bottom in a stuffing-box, through which a copper rod slides so as to reach above the level of the air-pump plate. The end of the rod supports a small horizontal platform of sheet brass, which receives four upright screws. These, by pressure on brass bars extending from one to the other, are competent to secure upon the platform a parallelopiped of charcoal. Upon the air-pump plate a glass bell is supported, and so fitted to it, by grinding, as to be air-tight. The otherwise open neck of the bell is closed air-tight by tying about it a caoutchouc bag, of which the lower part has been cut off, while into the neck a stuffing-box has been secured air-tight. Through the last-mentioned stuffing-box a second rod passes, terminating within the bell in a kind of forceps, for holding an inverted cone of charcoal (E).

The upper end of this sliding rod is so recurved as to enter some mercury in a capsule (F). By these means and the elasticity of the caoutchouc bag, this rod has, to the requisite extent, prefect freedom of motion.

The lower rod descends into a capsule of mercury (G), being, in consequence, capable of a vertical motion, without breaking contact with the mercury. It is moved by the aid of a lever (H), connected with it by a stirrup working upon pivots.

Several of the experiments made by Hare are described from his original paper, and Dr. Doremus sums up his work as follows: "Hare obtained, despite the disadvantages of a current from a primary battery, calcium carbide, phosphorus, graphite and metallic calcium, and there are just reasons, therefore, for regarding him as the earliest American scientific experimenter and discoverer in electrochemistry."

* * *

Synthesis of Hydrocyanic Acid.

A paper by Mr. E. W. Smith and Dr. R. S. Hutton deals with the results of an experimental investigation carried out in the University of Manchester, England, on the direct synthesis of hydrocyanic acid and cyanides from carbon and gaseous mixtures such as producer gas, containing nitrogen and hydrogen (Brit. Patent 23835, Oct. 26, 1906; see also former work by James Dewar, *Proc. Roy. Soc.*, vol. 29, p. 188, 1879, and vol. 30, p. 85, 1880, and later work by H. von Wartenberg, *Zeit. f. Anorgan. Chemie*, vol. 52, p. 299, 1907).

While Dewar belived that the temperature of the electric arc was necessary for the reaction, the experiments of the present authors show that hydrocanic acid can be formed at much lower temperatures.

The experiments of the authors were made in a closed vessel in which a rod of carbon was heated simply by Joulean heat, every precaution being taken to prevent arcing. In general, the experiments clearly prove that when carbon is maintained in contact with hydrogen and nitrogen below a temperature of some 1800° C., cyanide is not produced in noticeable quantities.

On the other hand, at all temperatures above about 1800° C. the reaction proceeds, HCN is produced, and the carbon rod shows evident signs of attack, disintegrating to quite a marked extent; moreover, the relative quantity of HCN formed rapidly increases with the temperature, experiments having been performed at different temperatures ranging up to 2500° C.

In the case of using the carbon rod in an atmosphere of ammonia, the production of cyanide is, as might be expected, increased, but it is of some interest to note that the temperature at which the reaction occurs is not to any marked extent lower than with nitrogen and hydrogen.

Finally, the production of cyanides from mixtures of gases containing CO, such as correspond to producer gas, has been shown to proceed satisfactorily, and particularly in this latter case the process is of practical value, on account of the difficulty and expense of preparing pure nitrogen.

Some preliminary experiments in this direction were carried out in a furnace containing two solid carbon electrodes in a surrounding charge of ground carbon. The portion of the charge between the two electrodes is heated to the maximum temperature and it is there that the formation of hydrocyanic acid occurs. This is then quickly withdrawn and cooled with sufficient rapidity to preclude the decomposition of HCN. For this purpose either one of the electrodes is hollow and has a central channel through which the gas is withdrawn or a separate water-cooled tube is provided which projects into the central zone of the charge between the two electrodes.

The gaseous mixture of nitrogen and hydrogen together with carbon monoxide is supplied to the apparatus and passes through the carbon charge so that it is preheated. When it reaches the central part of the charge the reaction starts and the gas which is formed is then quickly withdrawn.

While these experiments are only preliminary in some respects, they prove definitely that HCN is formed at temperatures very far below that of the electric arc and under conditions which almost certainly preclude the intervention of complicated electric effects such as are characteristic of the arc.

Some of the records of a few typical experiments made by the authors are given.

* * *

Power for Electrochemical Industries.

A paper by Mr. John Meyer was presented in abstract. The author is collecting statistical data, representative of the conditions in the more important central stations of this country, and also including data of the large power companies. These data are favorable to the supply of power from central stations to electrochemical works, but both parties—the central stations and the electrochemists—should understand each other. The electrochemist will be welcome as customer to the central station only if in that way the much-needed equalization of the load curve is obtained. Continuous electrochemical processes will not be suitable for such work, but only such processes as can be advantageously operated only at times of low load in the central station, or for about 20 hours a day. Central-station men and electrochemists should get together.

* * *

Alloying of Iron and Calcium.

At the Saturday morning session several interesting papers relating to metallic alloys were presented.

A paper by Messrs. A. Hirsch and J. Ashton, of the University of Wisconsin, was presented in abstract by Prof. Burgess. Former evidence as to the possibility of alloying calcium with iron is greatly conflicting. Many believe it cannot be done. The present authors have, however, succeeded in doing it and show that former failures have simply been due to the fact that calcium vaporized at the temperature of molten iron. But if calcium shavings are mixed with iron oxide in a closed, gas-tight steel cylinder and the charge is ignited, a very high pressure is produced within the cylinder and the vaporization point

of calcium is thereby reduced. It was thus found possible to include up to 6 per cent of calcium in the iron alloy.

However, such alloys are no good for practical purposes. Calcium in iron makes it very brittle. Even very little calcium makes itself very noticeable in iron. Calcium also destroys the welding properties of iron. The vaporizing point of calcium is between 1290° and 1300° C., and 1290° is assumed as the probable vaporization point at atmospheric pressure.

* * *

Calcium Alloys for Aluminothermic Work.

A paper by Dr. O. P. WATTS and Mr. J. M. BRECKENRIDGE, of the University of Wisconsin, on the preparation of calcium alloys for aluminothermic work was presented by Dr. Watts. In the reduction of refractory oxides by means of aluminium by the aluminothermic reaction of Dr. Hans Goldschmidt, the heat available for melting the reduced metal and the alumina slag is the difference of the oxidation heats of aluminium and of the metal to be reduced.

For the reduction of elements with a very high oxidation heat and a very high melting point, the reaction becomes more difficult. But there are several possibilities to improve matters. First the application of external heat, either by preheating the whole charge to a high temperature below the ignition point, or by adding the heat of the electric arc to that of the reaction.

Further, for industrial purposes, it is in some cases just as good to produce not the pure metal, but its ferro, for instance ferro-titanium. In this case Dr. Goldschmidt substitutes in his charge for a part of the oxide of titanium that of iron. Success is here obtained by the greatly increased heat of the reaction and the lower melting point of the ferro alloy.

The authors give a review of the various researches which have been made in recent years with respect to the aluminothermic process and then describe experiments made by themselves on the preparation of alloys of aluminium, calcium, magnesium and silicon, which they undertook with the hope of obtaining reducing agents which would possess a somewhat higher heat of oxidation per unit of oxygen than aluminium, and whose mixed oxides would form a much more fusible slag than alumina. It was also thought that there would be a decided advantage, so far as fluidity of the slag is concerned, in having the particles of the different oxides produced in intimate contact. This will be the case, to a far greater degree when the metals are alloyed, than when the different oxides are formed from isolated particles of each metal, as in a mechanical mixture.

Another object was to produce alloys of such brittleness that they could be easily pulverized to any degree of fineness (without using any special method, as in the case of aluminium).

Twenty-three different alloys of calcium with one, two or all three of the elements—aluminium, magnesium and silicon—were prepared by the authors. Their composition is shown in the table below.

No. of alloy	1	3	4	5	6	7	8	9	11	12	14	15
Formula						$CaMg_2$		$AlCaSi$	$AlCaMg$	$AlCaMg_2$	$Al_4CaMgSi_2$	$AlCa_2Mg_2$
Al	75%	74.5	45		60		50	28.4	29.7	23.5	41.4	17.4
Ca	25	25.5	55	30		45.5	30	42.	43.9	34.8	15.8	51.6
Mg				70	40	54.5	20		26.3	41.7	9.4	31.
Si								29.5			33.8	

No. of alloy	16	17	18	19	20	21	22	25	31	32	33	34	35
Formula												$40\ Al + 60\ CaSi_2$	$Al_2Ca_3Mg_2$
Al	93.8	90	84	67.1	80	80	27.2	60	65	45	60	40	24.3
Ca	6.4	10	10	12.9	20	12.5	72.8				40	25	54.1
Mg			6			7.5		40		20			21.6
Si									35	35		35	

The alloys were made in an electric furnace of the granular-resistor type, by melting the constituents together in crucibles of Acheson graphite. The method of operation was as follows: The crucible was set in the furnace, sufficient calcium chloride added to form a layer over the metals when melted, and the elements put in in the following order: Aluminium, silicon, magnesium, calcium, each as soon as the one previously put in had melted. Since the temperature was always much below the melting point of silicon, this element was taken up only by solution.

This was a rather slow process until the calcium or magnesium was added, when the silicon quickly dissolved. The alloy was stirred very thoroughly, and poured into a cast-iron mould. There was little trouble from burning of the calcium until this exceeded 70 per cent. In two attempts to prepare a calcium-aluminium alloy of over 85 per cent calcium, the alloy took fire and was lost. The time required to melt and pour a charge of about a pound varies from five to twenty minutes, depending on whether the furnace was hot or cold when the charge was put in, and upon the amount of calcium added.

Ten to twelve kilowatts was used for heating, although the current was often interrupted for a considerable portion of the time in order to keep the temperature to the lowest limit that would melt the metals. The alloys containing only calcium and magnesium were troublesome to prepare, as they were less dense than the protective layer of calcium chloride.

In appearance these alloys vary greatly, from the homogeneous glass-like structure of No. 6 (60% Al, 40% Mg), to the coarsely crystalline structure of No. 9 (28.4% Al, 42% Ca, 29.5% Si), which appears to be a mass of flat crystals ⅛ in. x ½ in. Their luster is metallic, and in most cases brilliant. They all decompose water at rates depending mainly on the amount of calcium or magnesium present. The addition of three drops of concentrated hydrochloric acid to 15 c.c. of water containing the alloys causes a considerable increase in the rate of evolution of hydrogen, and with the silicon alloys, yields a spontaneously inflammable gas, probably partly SiH_4. This causes sharp explosions in the test tubes.

The stability of the alloys in air is remarkable. After two weeks exposure in the laboratory, only one had disintegrated to an appreciable extent. As this alloy, No. 22, contained 73 per cent of calcium, its disintegration was to be expected. The other alloys appeared as bright as when made. This is in striking contrast to the rapid disintegration of copper-calcium alloys.

Several samples of these alloys were exhibited.

It is thus seen that alloys of calcium with aluminium and magnesium can be easily prepared up to a calcium content of 70 per cent.

All of the alloys prepared, containing 25 per cent or more of calcium or magnesium, can be readily pulverized.

Several of these alloys were then used in the aluminothermic reaction. The object was to reduce the compounds MoO_3, MoS_2, WO_3, SiO_2, Fe_3O_4, TiO_2 and mixtures of SiO_2 with MnO_2, of TiO_2 with MnO_2, and of TiO_2 with Fe_3O_4. The alloys so far tried are Nos. 8, 11, 14 and 15.

The first experiment was an attempt to reduce MoO_3 by alloy No. 8. The oxide was the usual fine powder of commerce, and the alloy is a mixture of all sizes that would pass a 20-mesh sieve. The reaction was very rapid, and was accompanied by the projection of melted material, flame and much smoke. At the end of the reaction the crucible was nearly empty, and contained no metal. Thinking that the sudden expansion of air contained between the particles of the charge might be responsible for much of the loss of material, the experiment was repeated in a vacuum cylinder constructed from a piece of 8-inch steam pipe. Less material was projected than before,

but the loss was still great. Forty grams of well-fused molybdenum was obtained.

Several other experiments were tried in vacuo. SiO_2 was only partially reduced, yielding a brown product resembling silicon monoxide in appearance. A mixture of MnO_2 and SiO_2, reduced by alloy No. 11 (AlCaMg), gave an excellent ingot of silicon-manganese, well separated from the slag. The yield was only 22 per cent of the theoretical, probably due to the large amount of material projected from the crucible. In order to reduce the velocity of reaction, pulverized fluorspar and lime were added to several charges, with a slight improvement in the yield of metal. After eight trials in the vacuum cylinder, experiments under atmospheric pressure were resumed.

Reduction of a mixture of MnO_2 and TiO_2 by No. 15 ($AlCa_2Mg_2$), in pieces ¼ to ⅛ of an inch in length, was violent, with much flame and smoke, and the projection of some slag. Only a few globules of metal were obtained. Other reactions were tried with quite similar results. The only alloy that gave quiet reactions was No. 14 ($Al_4CaMgSi_3$). This acted much like aluminium itself.

As a last resort the charges were fired inside a closed steel cylinder, designed to withstand a pressure of 10,000 pounds per square inch. With this apparatus, several difficult reductions were carried out. Mixtures of the alloys with molybdenite in theoretical proportions failed to react, but on adding a large excess of alloy and enough calcium peroxide to oxidize it, an ingot of well-fused metal was secured.

The most difficult reduction carried out was that of rutile. By the use of calcium peroxide, a single button weighing 15 grams, and many globules, were obtained. The metal is hard, though not sufficiently so to scratch glass. It is not in the least malleable, and is broken by severe pounding with a hammer. In appearance it resembles freshly broken Goldschmidt manganese. A qualitative test shows the presence of aluminium, apparently in rather small amount. It is hoped that further experiments may lead to the elimination of this impurity. Until this is attained the reduction cannot be considered a complete success.

All attempts to obtain tungsten from WO_3 failed.

The cause of the violent nature of the reductions by aluminium-calcium-magnesium alloys, whether carried out in air or in vacuo, whether the materials were coarsely or finely pulverized, was for some time very puzzling. The following explanation is offered:

When all the products of reaction are non-volatile, and no gases are present, it would seem that mere rapidity of reaction should not throw half the material from the crucible. If the cause does not lie in the volatile nature of some product, nor in the speed of the reaction, it must be sought in the original charge, and it is here that the authors believe that the difficulty lies—in the low boiling points of calcium and magnesium. The boiling point of Mg is given at 1100° C. and that of Ca as about 1,300° C.

Besides confining the charge in a gas-tight cylinder, another method of preventing this vaporization of calcium was tried. Since calcium silicide is a product of the electric furnace, it ought to be stable at a very high temperature. It should follow that if all the calcium put into a thermit charge is in the form of calcium silicide, none of the metal can be evaporized until the silicide is decomposed by oxidation. When a molecule is broken up by attraction from outside, that element in it which has the greater affinity for the destroying agent is not the one which will "get left" in the struggle for oxygen.

Alloy No. 34 (40% Al, 60% $CaSi_2$) was prepared to test this theory. In two reactions with Fe_3O_4, in open crucibles, there was no projection of material, and the reduction was very successful. The presence of this amount of silicon in the reducing agent, either free or combined, would greatly reduce the temperature attained. It is possible that the effect observed was entirely due to a diminished heat of reaction rather than to the reason assigned; yet the fact that the temperature was high enough for iron to be perfectly fluid, leads the authors to consider these experiments as evidence in confirmation of their theory.

The cost per pound of materials entering into the alloys was: Aluminium, $0.43; calcium, $1.50; magnesium, $1.25; silicon, $0.15. The cost of materials in three of the alloys was: $1.14 per pound for No. 11, $1.36 for No. 15 and $0.58 for No. 14. Silicon appears to be the only cheapening material at present available for addition to aluminium or its alloys, when they are to be used for aluminothermic processes.

The paper was briefly discussed by Messrs. Betts, Comey and Richards. In view of the fact that there is a tendency to substitute other elements for aluminium as reducing agent in the aluminothermic reaction, it was suggested by Dr. Richards to speak of the "metallothermic" reaction. Another name suggested was "elementothermic." It was stated that the manganese produced by Dr. Wahl, of Philadelphia, by reduction with aluminium, had some properties different from the present Goldschmidt manganese; this may have been due to contents of aluminium or silicon in Dr. Wahl's manganese. It was also suggested to use some of the alloys described in the paper for flash-light purposes.

* * *

Electrolytic Conduction.

A paper by Dr. Louis Kahlenberg, of the University of Wisconsin, was presented in abstract by Professor Burgess. Dr. Kahlenberg discusses the attempts which have been made to find out something concerning the nature of electrolytic conductors; that is, especially the question what other peculiar chemical or physical properties electrolytic conductors have, besides the one of conducting the current with concomitant chemical decomposition, to which the latter power may be ascribed.

Hittorf was of the opinion that electrolytes are salts (in the wider sense so as to include acids and bases). Arrhenius claimed that solutions showing abnormal vapor tension, abnormal lowering of the freezing point and abnormal elevation of the boiling point (where abnormal means a discrepancy from Vant' Hoff's gas theory of solutions) are electrolytes, and that in these solutions the dissolved substance is decomposed into positively and negatively charged part-molecules. However, Dr. Kahlenberg claims that this generalization does not hold true. As an example he mentions aqueous soap solutions, which boil at practically the same temperature as pure water, and yet are excellent electrolytic conductors. "The fact must calmly be faced that the vapor tension of solutions, and for that matter any other single physical property so far as we know, does not afford any basis whatsoever of a correct view as to the nature of electrolytes as contrasted with non-electrolytes."

In any consideration of the conduction of electricity the great fact that the best conductors are metals ever looms up before us. If an alloy is formed from two metals it is also a conductor. If a metal combines with an element or elements of non-metallic character, the resulting combination may be an electrolyte or an insulator. Tin is a conductor, chlorine an insulator. Stannous chloride is quite a good electrolyte when fused. Stannic chloride is an insulator throughout the entire range of temperature from the solid state through the melting point to the critical temperature and beyond. It looks as though the conducting power of the tin is gradually annihilated as more tin is added. "In general, one may say that every element tends to preserve its properties as it enters a compound, so far as the other ingredients in the compound will permit it to do so" or "as far as the new conditions, under which it is placed, in the compound will permit."

A great difficulty arises in explaining why certain substances and solutions which contain no metals at all conduct electrolytically and others do not. "One might well hold that the electrolytes which do not contain metals have yet a property characteristic of compounds containing metals * * * In this

category we have notably acids and salts of non-metallic bases. The hydrogen of acids has always been considered by chemists as having metallic characteristics, and the fact that liquid hydrogen has, after all, been found to be a non-conducting, colorless liquid, and solid hydrogen a colorless transparent solid has been somewhat disappointing to many chemists."

Further, it is not easily comprehended why in certain cases the union of two very poor conductors should result in a very good electrolyte. A typical example is the solution of acetic acid in water, which conducts well while the two pure substances alone are very poor conductors. But "all our notions as to the chemical constitution, so-called, of a compound are derived from the mode of building up or tearing down that compound and its behavior towards reagents. Our efforts to trace the power to conduct electrolytically to the chemical constitution of a compound are, therefore, simply efforts to find a relationship between electrolytic conductivity on the one hand and the behavior of the substance in question toward other chemical reagents on the other."

"We do not know why a piece of silver conducts and a piece of sulphur does not, though the experimental fact in question has been known for a long time; and we are really much more in the dark as to why some compounds conduct electrolytically, others do not conduct at all, and still others conduct without decomposition. A frank acknowledgment of the actual situation seems to me very desirable, for it is bound to stimulate inquiry that will lead to a better comprehension of the phenomena of conduction." We must have very much more intelligent experimentation on the subject of electric conduction in general and electrolytic phenomena in particular before we can hope for a real improvement of our theories of the interrelation of electricity and matter, and our views of the process of electrolysis and the nature of electrolytic conduction.

* * *

Direct Current in Electrolysis Without Electrodes.

A paper by Mr. CARL HERING suggests that experiments in which a direct current is made to flow through a complete circuit of electrolytes, without any electrodes, might answer some fundamental questions as to the nature of electrolytic conduction and the ionic theory. Mr. Hering described various experimental arrangements in which this result can be obtained.

The simplest way to produce a current in a complete circuit

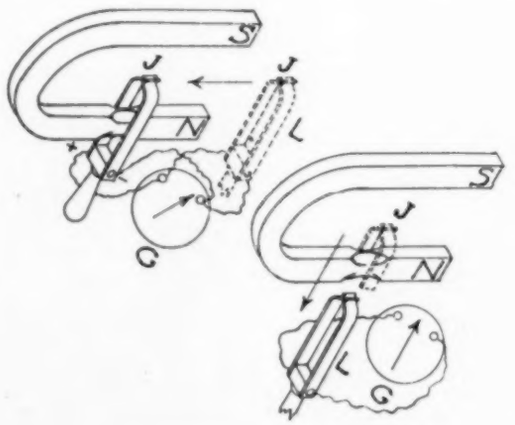


FIG. 5.—EXPERIMENT IN INDUCTION.

of electrolytes, without electrodes, would seem to be to induce it electromagnetically, as is done in transformers. But, according to the law of induction, as given by Maxwell and as usually stated in text-books, it would be impossible to produce a prolonged direct current in a closed circuit in this way, because it is, of course, impossible to continue indefinitely to increase (or decrease) the magnetic flux enclosed by such a circuit; and according to that law as it is usually stated, it would be impossible to alternately increase and diminish this flux without producing an alternating current.

But Mr. Hering has recently shown* that the law as usually stated, is incorrect. It is possible to get a direct current by repeated cutting of the same flux, namely, by cutting it in one direction with the conductor and in the reverse direction with the circuit only, the conductor remaining at rest, relatively to the flux. (See foot note.)

Another method is suggested by a recent experiment of Dr. Northrup (*Phys. Review*, vol. 24, June, 1907). Two bar magnets are mounted radially in a vertical beaker containing an electrolyte, with like poles toward the central axis, around which they are capable of rotating. If now a current is passed vertically through the electrolyte, these magnets will revolve, owing to the horizontal circular lines of flux in the electrolyte, due to the current.

Reversely, Mr. Hering concludes, a direct current will be induced in the electrolyte, if the magnets are revolved by an external power.

Various other arrangements, which may be used to advantage for experimental research, are also described in some detail, but no such experiments have yet been actually carried out.

The paper was briefly discussed by Messrs. Bancroft, Breed, Burgess, Lidbury and Richards.

* * *

Reversed Electrolysis.

A paper by Mr. J. W. TURRENTINE, of Cornell University, was presented in abstract by Dr. Bancroft. It dealt with apparently abnormal reactions at the electrodes of an electrolytic cell. A case in point is the deposition of gold from an alkaline carbonate solution on the anode. We have here to do with a secondary precipitation of gold from the primary anodic product of electrolysis. Under certain conditions it is also possible to produce hydrogen at the anode and oxygen at the cathode. Various cases of this kind were described and explained. The paper was briefly discussed by Messrs. Betts and Lidbury.

* * *

Dry Cells for Ignition.

A paper by Dr. J. W. BROWN, director of the Research and Battery Laboratory of the National Carbon Company, dealt with the use of dry cells on ignition service. While the dry battery was early in the ignition field, it has often been used, and is still being used, in a very inefficient manner, so that some operators of gas or gasoline engines have turned to the storage battery. But things will be different when the proper use of dry batteries is better understood.

Most gas or gasoline engines are equipped with an ignition apparatus consisting of a spark plug, a transformer spark coil and a make-and-break device or timer. It is the function of the timer to close the battery circuit through the primary circuit of the spark coil at the proper moment in the engine cycle and for a sufficient period or interval to allow the current to rise to such a value as to be capable of being transformed by the spark coil into one which will pass the spark gap in the engine and ignite the explosive mixture of gases. The battery circuit

Proc. Am. Inst. Elec. Eng., March, 1908, p. 339. Mr. Hering's fundamental experiment is as follows: A loop L in the left-hand diagram of Fig. 5 was formed of two flexible strips whose ends pressed together at joint J, and the circuit of the loop was closed through a galvanometer G. On moving this loop over one leg of a U-shaped permanent magnet NS from the dotted position to that shown in full, an electromotive force was induced, as is well understood. The magnetic flux has thereby been linked with the electric circuit, the flux enclosed by the circuit has been increased from zero to the maximum; or, to use Faraday's terms, the lines of force in the air from one pole to the other have been cut by the conductor. If this loop is now moved, as shown in the right-hand diagram from the dotted position to the one shown in full, by passing the leg of the magnet through the joint J of the loop, but without opening the circuit, the flux and the circuit will be unlinked again; that is, the flux enclosed by the circuit will again be reduced from a maximum to zero, and the circuit will have cut the same lines of force in the opposite direction, as it is well known that all the flux of this magnet passes through its interior. But there is absolutely no e.m.f. induced by this unlinking. To get an e.m.f. it is necessary that the conductor itself (not the circuit) cuts the lines of force; and it is thus necessary to distinguish between conductor and circuit.

should be closed through the coil only for exactly the right period to prevent a waste of battery energy.

From the standpoint of the efficient use of dry-battery energy the usual types of timers are faulty in having excessively long contacts; variable with the speed at which the engine is running, and the usual types of spark coils are faulty in requiring too high an amperage per spark, and in producing too many sparks per explosion. The magnitude of the waste of battery energy from these sources is evident from the following comparisons:

Efficient ignition can be produced with a contact of a duration of 0.005 second and with a single spark per explosion at all speeds of the engine. The resulting drain on the battery corresponds to a continuous current of about 0.05 of an ampere. In spite of these facts the period of contact of the chief forms of timers varies from 0.01 to 0.05 of a second, according to the speed at which the engine is running, and the number of sparks given by the most-used types of spark coils varies from 4 to 10 or 15 per explosion. The resulting drain on the battery corresponds to a continuous current of 0.3 to 0.6 of an ampere when the engine is running and the vibrator of the spark coil is properly adjusted. In some cases which have come to Dr. Brown's attention the drain was increased, by faulty adjustment of the vibrator alone, from about 0.5 to over 3 amperes. These statements were illustrated in a very interesting way by means of apparatus exhibited at the meeting.

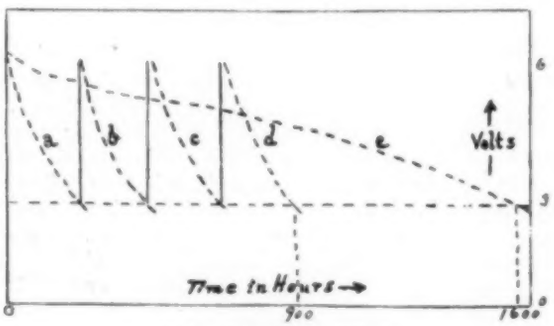


FIG. 6.—DISCHARGE CURVES.

Dr. Brown has found that over 90 per cent. of the trouble experienced with battery ignition is due to the use of poorly designed ignition apparatus or the use of well-designed apparatus badly adjusted.

The ignition apparatus should consist of a spark plug of the usual types, of a single transformer spark-coil with a mechanical make-and-break in the primary circuit driven by, but independent of the speed of, the engine, and of a distributor which sends the induced high-potential current to the various cylinders of the engine in rotation. Such an apparatus would produce a single hot spark per explosion.

Turning now to the dry battery itself, Dr. Brown emphasized that the chief requirement of a dry battery for ignition service is not simply to furnish a given quantity of electrical energy, but to furnish it in the form of impulses of 2 amperes or more in rapid succession through a resistance of about 0.5 ohm.

Initial amperage and initial voltage readings so widely used in dry battery tests, do not serve to disclose the ability or lack of ability of the dry battery to give long ignition-service life. While the available energy is an important factor, the internal resistance, not of the unused battery, but of the battery while on service, is a second important factor in determining the value of the battery for gas-engine work, and the size and arrangement of cells in the battery necessary for best results. In this second respect two cells, with the same available energy, may differ greatly, as was shown by curves. The difference is caused by the increase in internal resistance due to mechanical clogging of the cells during discharge—and is only developed by actual discharge.

According to present standards and present methods of using dry cells, i. e., in the form of a single series of cells or battery, the one cell may and the other cell may not be capable of giving good ignition service. If, however, both types of cells were used in the form of series-parallel batteries of two, three or four sets of cells in parallel, not only would practically the same good service be obtained from each type, but also in each a very much longer service would be obtained than when used in batteries of a single series.

This is evident from the discharge curves shown in Fig. 6, where curves *a, b, c* and *d* represent the decrease in working voltage of four single series batteries of four cells each similar to present ignition practice, while curve *e* represents the decrease in working voltage with four batteries of the same kind connected up in parallel to form a single series-multiple battery in which the average drain and the impulse required from each cell is reduced to one-fourth of the corresponding values required from each cell in the single series batteries. A gain in service life of 100 per cent. is shown.

It is a natural conclusion from such results that, both in respect to reliability and in respect to length of service life, dry cells of the 6-in. size should not, except in case of emergency, be used in the form of a single series battery, but instead they should be used in the form of series-multiple batteries with as many as four sets in multiple whenever possible. Practically all dry battery troubles not caused by the use of ignition apparatus of poor design or adjustment may be located in the use of a battery of a form and size not adapted to the service required of it. Given a good ignition apparatus and a battery of proper size and form, dry cells are capable of furnishing electrical energy for gas or gasoline ignition with an economy and a reliability exceeded by no other means now in general use.

In the discussion which followed, President Burgess remarked that, from an industrial point of view, the dry cell is a very important electrochemical piece of apparatus, there being used in this country from 30,000,000 to 50,000,000 dry cells per year. The usual test of taking a reading of the initial amperes by short-circuiting the cell through an ammeter is really foolish, but for the sake of competition manufacturers build their dry cells so that they give high initial values and must jeopardize to some degree other more valuable qualities. Some remarks by Messrs. Hering, Fleming and Brown referred to details of the electrical tests made in this investigation.

* * *

Electrolytic Corrosion of Aluminium Bronze.

A paper by Mr. W. S. Rowland, of Cornell University, was presented in abstract by Dr. Bancroft. The paper gives the results of an experimental investigation of the corroding effects of the more common sodium salts and of sodium hydroxide upon aluminium bronzes of different composition. The results are interpreted with the aid of the equilibrium diagram of phases. It is shown that unless caused by some additional chemical action, the changes in the rates of corrosion only occur upon the appearance or disappearance of a phase, as shown in the equilibrium diagram. It is possible that the alloy containing from 10 to 20 per cent copper may be very serviceable for metal parts which are subject to the weather.

* * *

Corrosion of Bronzes.

Dr. A. T. Lincoln, of the University of Illinois, presented in abstract an account of further researches on the electrolytic corrosion of the bronzes. He has formerly made detailed and very elaborate investigations on this subject, which may be found in full in Vol. XI, p. 43 of the *Transanctions of the American Electrochemical Society*. While he had formerly studied corrosion by different separate salt solutions, he has now made tests in a mixed solution, namely, in synthetic sea water. The curves showing the results are quite in accordance with his former results. The corrosion in sea water is of the same general character as corrosion in a sodium chloride solution.

Electric Distillation of Turpentine.

A paper by Mr. F. T. SNYDER, who is best known by his activity in electric zinc smelting, deals with a plant in which turpentine is distilled by electricity on a commercial scale in Canada.

Pine woods contain a series of volatile hydro-carbons having boiling points varying from 130°C. to 250° C. A mixture of these, including the groups which boil between 155° C. and 170° C., forms what is commercially known as turpentine. The principal constituent of this turpentine is pinene, with a boiling point of 155° C. to 156° C. The process of obtaining turpentine from wood by distillation is an expensive one, in that the turpentine exists in the wood substantially in the form in which it is obtained, and is not a product of decomposition at the time of extraction. At 175° C., the pinene of the turpentine begins to break up into a mixture of lighter and heavier hydro-carbons, the decomposition being substantially complete at 270° C. It is therefore necessary to distill turpentine within ralatively narrow temperature limits.

The plant is erected at Vancouver, B. C., where a considerable supply of waste fir wood is available in the form of saw-mill refuse and cheap electric power is also available. The plant has a capacity of three cords per day and has been in operation since July, 1907.

The wood supply for this plant is brought in by barge from neighboring sawmills, and landed at a dock adjoining the plant. On this dock the wood is filled into cans, which are wheeled into the plant, picked up by an overhead crane and dropped into a brick retort, forming one of a group which are placed together to reduce radiation. The top of the can forms a flange, which dips into a groove around the top of the retort, filled with tar, forming a gas seal when the can is in the retort. Electricity at 110 volts is carried through wrought-iron strips threaded through the brickwork on each side of each retort.

By means of direct reading pyrometers the temperature outside of and at the center of the can is measured. The turpentine vapor which is distilled off is taken from the retort through a removable copper outlet pipe to the condenser, which consists of an upright copper pipe, down which a spray of water is passed through the ascending turpentine vapor, and which terminates in a tank at the bottom. The tank serves as a separator for the condensed turpentine and water, the turpentine readily floating to the top of the water.

The brickwork of the retort, when a can newly filled with wood is put in it, is about 250° C. The cold can rapidly absorbs heat from this brickwork, the temperature of the brickwork being kept up by a current of 400 amperes, which is put through the resistance strips for about two hours. During this time, the temperature at the outside of the can rises from 75° to 130° C., at which turpentine begins to come off and at which time the center of the can is at 45° C. The current is then shut off, and the temperature of the can slowly rises by absorption of heat from the brickwork for two hours longer, when the temperature has reached 150° C. on the outside of the can and 205° C. in the center of the can and the turpentine has been substantially all removed. In practice it is found that from 90 to 95 per cent. of the turpentine in the wood, as determined by analysis, is removed during this interval. While the turpentine is coming off, the pitch in the wood melts and runs down to the bottom of the can and out through perforations, and is collected in the bottom of the retort, from which it is drawn off, at the end of the run, into the barrels in which it is shipped.

The fact that the temperature at the center of the can at the end of the turpentine run is higher than outside is due to the decomposition of the hydro-carbons in the woods, which reaction liberates heat. In order to keep the turpentine condenser and piping from being fouled by tar oil or tar products, it is therefore necessary to lift the can now by the overhead crane from the turpentine retort and put it into an adjoining retort.

In its new position the can is now connected up by another copper pipe to a second condenser and due to the continuous decomposition of wood with rising temperature, without any further use of electricity, tar oil goes off as vapor and is condensed while wood tar trickles down (as the rosin does in the turpentine retort) and is collected in the bottom of the tar retort.

At the end of three hours of the tar run, the temperature in the center of the can has risen to 375° C. and tar oil and tar stop coming off. The can is then lifted out and stood on a sand floor, which makes an air seal with the lower edges of the can and protects from combustion the contents of the can, which now consists of charcoal. When the can and its charcoal contents are cool, which takes about three hours, the perforated bottom of the can is tripped and the can lifted, allowing the charcoal to fall out. This charcoal is then put in sacks, as required by the trade which consumes it. The charcoal is tough and suitable for special purposes.

In practical work there are obtained per thousand pounds of wood 6.7 gallons of turpentine, 168 pounds of rosin, 5.1 gallons tar oil, 68 pounds tar and 323 lb. charcoal. There are used 90 kw. hours per can of a thousand pounds of wood and the cost of these 90 kw. hours at Vancouver is 18 cents only. The plant is operated by one man on each shift, there being two 12-hour shifts per day. When the wood is large an extra man is employed on the day shift to split it.

* * *

Concentration of Mixed Sulphide Zinc Ores.

A paper on the corrosion of iron pyrites into a magnetic form by Mr. O. L. KOWALKE, of the University of Wisconsin, was presented in abstract by Prof. C. F. Burgess.

One of the important problems in preparing mixed sulphide zinc ores for the smelting operation is the removal of iron pyrites. A method commonly employed for removing the iron pyrites is first to convert the non-magnetic sulphide to a magnetic form by roasting the ore in a furnace where the products of combustion come in direct contact with the ore. After cooling, the roasted product is treated by a magnetic separator.

In this roasting process some of the ore frequently becomes heated to an excessive temperature, and in the presence of oxidizing gases, red oxide of iron is formed which is non-magnetic. The purpose of the investigation described in this paper was to determine the temperature and the various atmospheric conditions under which iron pyrites can be made magnetic; also the loss of sulphur necessary for the attainment of this condition.

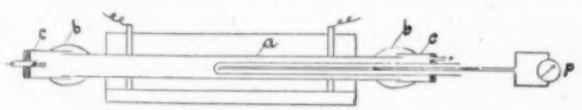


FIG. 7.—ELECTRIC FURNACE.

The experiments were made in a granular carbon resistance furnace of the construction shown in Fig. 7.

The furnace, whose inside dimensions were 3 in. x 2½ in. x 13 in., was built of fire brick. A Royal Meissen Porcelain tube (*a*), 26 inches long, one inch internal diameter and glazed on the inside, served as the chamber in which the ore was treated. This tube, surrounded by the graphite resistor, lay lengthwise in the furnace. The furnace terminals were graphite slabs straddling the tube. To provide for suitable stoppers for the ends of the tube, glass sleeves (*c*), about 3 inches long, were slipped over the ends of the porcelain tube and cemented on by a mixture of magnesia and water glass (*b*). Besides providing for a stopper of sufficient size to admit the placing of inlet and outlet tubes, these glass ends served also to prevent heat conduction from the porcelain to the stopper.

A thin layer of charred paper around the tube served to prevent any pitting action on the porcelain by the hot resistor particles even at temperatures above 1000° C.

An alternating current at about 33 volts was sufficient to give

the heat desired. The voltage, when applied to the furnace, brought the tube up to temperature quickly, and then by regulating the voltage, the temperature was maintained easily within 10° C. of the point desired.

The temperature was measured by a Le Chatelier pyrometer with galvanometer P. A Kipp gas generator served for supplying the gas necessary for the various tests.

The electromagnet used was 2½ inches external diameter and 6 inches long. With a magnetizing current of 6.2 amperes in the winding, a flux was obtained sufficient to hold up 4830 grams of soft iron.

In all cases the material used was pure marcasite. This was crushed and sized, and that portion which passed a 20-mesh sieve and caught on a 40-mesh, was used for the tests. Great care was taken in the handling of the furnace and in the measurements made. After sealing the furnace the gas in which the ore was to be tested was passed through for at least 20 minutes to insure complete expulsion of air before the current was applied. The furnace was heated slowly to insure an even distribution of heat; this usually took an hour or more.

When the desired temperature was attained it was kept at that value within about 10° C. by regulating current and voltage on the furnace. After the ore had been treated a sufficient length of time, the current was cut off, but the gas allowed to pass through the tube until the temperature had fallen to at least 180° C. before the tube was opened. The ore was then removed and tested under the magnet for magnetic qualities. In all cases the magnetizing current was kept close to 6.2 amperes.

For testing in air the procedure varied somewhat from the general scheme; the heating tube was open to the air at one end and the ore was roasted in a closed cylinder to avoid too much exposure to oxidation. A cylinder of iron ⅛ in. diameter and 1 in. long, closed at both ends, with the exception of a small hole to allow the escape of fumes, proved unsatisfactory.

The sulphur vapors, which were driven off, attacked the iron and a fluxing action between the iron and ore took place so that it became impossible to account for losses. A porcelain cylinder of the above size, whose ends were closed by stoppers, each with holes of 1/32 in. in diameter, gave the best results. Thus an atmosphere composed of sulphur vapors and air was attained.

The furnace was first brought up to temperature and then the charged cylinder put in the tube. After heating the cylinder and charge this was taken out into the air and left to cool. When cool the separation tests were made with the magnet. The magnetic portion varied in color from a black to blue-black, while the non-magnetic residue was yellow.

In these tests made at atmospheric pressure the ore became magnetic at about 700° C. When the atmospheric pressure was reduced by about 45 mm of mercury, the ore became magnetic at a temperature about 150° lower than under atmospheric pressure and in half the time. The appearance of the roasted ore particles was bluish black. Only the outside layer of the particles had changed color, for the inside was yellow and apparently unaffected.

Tests were then made in an atmosphere of hydrogen (made from electrolytic iron and hydrochloric acid). In this case marcasite began to be changed to a magnetic sulphide at the low temperature of 494° C. The resultant grains are blue-black in color, due to a thin magnetic layer, for the inside was still yellow. Another interesting observation made in these tests was that hydrogen sulphide still seems to exist at the high temperature of 1,172° C.

The next series of tests were made in carbon dioxide. Sulphur vapors appear at about 507° C. The marcasite is made magnetic at about 600° C. or somewhat less. In an atmosphere of carbon monoxide marcasite is rendered magnetic at a temperature about 80° lower than in carbon dioxide. From these tests it also seems possible that FeS_2 can be reduced to metallic iron by carbon monoxide at a temperature below 600° C. Finally tests were made to determine the temperature at which sulphur is given off.

The chief results of the paper are summed up as follows: "It is not necessary to roast pyrite or marcasite to a homogeneous mass in order to obtain a magnetic product. A loss of sulphur of from 3 to 12 per cent. is sufficient to produce a coating, such that its magnetic properties will cause the whole particle to be picked up.

"Roasting in a reducing atmosphere and under a slightly reduced pressure requires a lower temperature than in a neutral atmosphere, and causes a smaller loss of sulphur to form a magnetic product.

"In a neutral atmosphere, sulphur begins to distil from FeS_2 at about 510° C. and continues to come off up to about 680° C. The roasting could be stopped slightly above 600° C., providing the atmosphere is neutral. If the temperature is increased beyond 680° C. the sulphur is driven off until FeS_2 results.

"Marcasite can be reduced to metallic iron in an atmosphere of hydrogen."

* * *

Electrolytic Refining of Iron.

A paper by Dr. Edward F. Kern, of the Department of Metallurgy, School of Mines, Columbia University, deals with the electrolytic refining of iron. The author first gives a review of what has been done before in this field, especially by Burgess and Hambuechen (see our Vol. II, p. 183) and others, and then gives the results of an experimental research carried out by him with the following electrolytes: (a) Solution of ferrous sulphate; (b) solution of ferrous sulphate containing sodium sulphate; (c) solution of ferrous chloride containing sodium chloride, and (d) solution of ferrous fluosilicate.

The fluosilicate was selected, as this iron salt is very soluble in water and since it had been found that neutral electrolytes of nickel fluosilicate give very flexible, bright and smooth deposits of nickel, it was hoped that the same would be the case with iron. The electrolytes were made up as follows:

(a) The ferrous sulphate solution contained 40 grams $FeSO_4 . 7H_2O$ per 100 cc., giving an electrolyte containing about 8 per cent. of iron (8 grams Fe per 100 cc.). (Solubility: 100 cc. of water at 20° C. dissolve 48.3 grams $FeSO_4 . 7H_2O$.)

(b) The ferrous-sodium sulphate solution contained 30 grams $FeSO_4 . 7H_2O$ and 21 grams $Na_2SO_4 . 10H_2O$ (Glauber's salt) per 100 cc., giving a solution containing about 6 per cent. of iron and 3 per cent. of sodium. (Solubility: 100 cc. water at 20° C. dissolves 44 grams $Na_2SO_4 . 10H_2O$.)

(c) The ferrous-sodium chloride solution contained 28.5 grams $FeCl_2 . 4H_2O$ and 10.2 grams NaCl per 100 cc., giving an electrolyte containing 8 per cent of iron and 4 per cent of sodium. (Solubility: 100 cc. water at 20° C., dissolves 64.3 grams $FeCl_2 . 4H_2O$; 100 cc. water at 20° C. dissolves 35.8 grams NaCl); 1 cc. conc. HCl per 100 cc. electrolyte was added in order to clear the solution.

(d) The ferrous fluosilicate ($Fe\,Si\,F_6$) solution was prepared by taking a calculated amount of dilute fluosilicic acid, containing 31 per cent. of $H_2\,Si\,F_6$, and neutralizing it with metallic iron, short-circuited with a strip of platinum, similar to an electric cell. The temperature of solution was kept between 55 and 65° C. until it was almost neutralized. Below 40° C. the reaction was very slow. (A small amount of free acid was left.) The nearly neutral solution of $Fe\,Si\,F_6$ was diluted so as to contain about 8 per cent. of iron. It was of light green color, clear, and did not oxidize so rapidly as the solutions of ferrous sulphate and ferrous chloride.

The fluosilicic acid was prepared by digesting a calculated amount of pulverized quartz in a platinum dish with hydrofluoric acid solution, containing about 35 per cent. HF. The reaction produced sufficient heat to cause the solution to boil. It was cooled by adding a small amount of water, to prevent loss of $Si\,F_4$ by distillation.

$$Si\,O_2 + 6\,H\,F = H_2\,Si\,F_6 + 2\,H_2O.$$

The $Fe\,Si\,F_6$ solution was kept in an ordinary glass bottle,

and the electrolysis was conducted in glass beakers. There is scarcely any corrosive action of the solution on glass.

The results of the experiments of the author are given in great detail in form of tables. They are summarized as follows:

Neutral ferrous fluosilicate electrolytes are not suitable for electrolytic refining of iron, as they are slowly decomposed with the separation of silica, which settles to the bottom of the cell and also collects in the anodes and cathodes.

The deposits from ferrous fluosilicate electrolytes are smooth and solid, of dull gray color and very brittle, due to the contained silica.

The e.m.f. required for electrolysis of ferrous fluosilicate electrolytes with a current density of 10 to 20 amperes per square foot was 0.9 to 1.2 volt when the temperature was 20° C., and 0.55 to 0.70 volt when the temperature was 60° C.

Good deposits of iron were obtained by the electrolysis of neutral electrolytes containing either 8 per cent. of iron as $FeSO_4$, or 6 per cent. Fe and 3 per cent. Na as sulphates, or 8 per cent. Fe and 4 per cent. Na as chlorides.

The e.m.f. required for electrolysis of neutral $FeSO_4$ electrolytes containing about 8 per cent. Fe with a current density of 10 to 20 amperes per square foot was 1.15 to 1.40 volt when the temperature was about 20° C., and 0.80 to 0.98 volt when the temperature was about 50° C.

The e.m.f. required for electrolysis of neutral sulphate electrolytes containing about 6 per cent. Fe and 3 per cent. Na, with a current density of 10 to 20 amperes per square foot, was 0.95 to 1.20 volt when the temperature was about 20° C., and 0.50 to 0.85 volt when the temperature was about 50° C.

On starting the electrolysis of sulphate and chloride electrolytes, the deposits of iron peeled from the cathode and curled, due to the presence of ferric salts in the solution. After the solutions were electrolyzed for about three hours the deposits formed smooth, solid and adherent.

Boiling the solutions previous to electrolysis liberated the dissolved gases and caused the deposits to form less pitted.

The deposits of iron formed smoother when the electrolysis was conducted at 40 to 60° C. than when conducted at normal temperature.

The deposits formed in neutral chloride electrolytes, containing iron and sodium chlorides, were finer grained and more flexible than those formed in neutral sulphate electrolytes.

The deposits of iron formed in neutral sulphate or chloride electrolytes, containing no ammonium salts, became quite malleable when they were heated above redness. The deposits from the chloride electrolytes, being finer grained, were the most ductile and could be hammered double after being heated.

The deposits of iron from electrolytes containing ammonium salts were harder, more brittle and also less rapidly oxidized than those from electrolytes which contained no ammonium salts. This suggested the possibility that deposits of iron formed in neutral ferrous-ammonium electrolytes contained either a nitrate or an ammonium compound of iron.

When the electrolytes are not protected from the atmosphere it is necessary to occasionally add a few drops of acid in order to clear the solution by dissolving the resulting basic salts.

When the electrolytes are not in use they may be maintained in the ferrous condition by placing in stoppered bottles and adding a few pieces of wrought iron, either wire or strips.

In the discussion which followed, Dr. J. W. Richards expressed the opinion that the time had come to start electrolytic iron refining on a commercial scale, the electrolytic iron product to serve as raw product for the manufacture of carbon-free ferroalloys and high-grade special steels. Since the process does not seem to be covered by patents, there is nothing more required than a little missionary work and some commercial enterprise. Prof. Burgess pointed out that while his process had been in satisfactory operation continuously for several years in his laboratory, yet in carrying it out on a commercial scale some new problems would come up which would have to be solved. Nevertheless, the cost of refining would be low. As to Dr. Kern's paper, it was important to know that chloride solutions gave satisfactory deposits, since they were superior to a ferrous and ammonium sulphate solution, as they could not produce any content of nitrogen in the iron. But Dr. Kern's experiments had not been carried out for a period long enough to say how the methods would work in continuous operation on a commercial scale.

* * *

Surface Film on Aluminium.

The last paper presented related to the nature of the surface film formed on aluminium and magnesium and the aluminium and magnesium cell (concerning which see *Transactions Amer. Electrochem. Soc.*, vol. X, p. 55), the authors being Dr. H. T. BARNES and Mr. G. W. SHEARER, of McGill University. Oxygen dissolved in the electrolyte on the surface of aluminium plays an important part. The aluminium reacts with the dissolved oxygen to form H_2O_2; hence the addition of this reagent to the cell which was formerly shown to augment the e.m.f. only increases the concentration of the substances already formed. The reaction is perhaps:

$$2Al + 6H_2O + 6O = Al_2(OH)_6 + 3H_2O_2$$

This suggests the nature of the film which is formed on the surface of aluminium when exposed to moisture and which plays an important part in the aluminium rectifier.

If a current is passed through the cell making the aluminium an anode, then the reaction is hastened, more peroxide is formed, and more hydroxide is produced. If the aluminium is cathode, as it is in the normal working of the aluminium-magnesium cell, then the peroxide is reduced and the film removed. Hence, when short-circuited the resistance of the cell is much reduced and the current increased, the e.m.f. being that produced by the presence of hydrogen peroxide around the aluminium.

Schulze has recently studied other metals with respect to non-symmetric conductivity. This he attributes to a thin layer of gas or oxide on the surface, which gives rise to various effects.

The fact that H_2O_2 may be produced in measurable quantities when aluminium is immersed in pure water charged with oxygen and not in oxygen-free water indicates directly the nature of the surface film which is formed and which has been the subject of so much discussion by previous observers.

In the discussion which followed, Dr. Whitney asked for information how the aluminium rectifier works in practice. Prof. Burgess said that it was very promising before the arrival of the mercury-vapor rectifier. But the aluminium rectifier has one great disadvantage, namely, that in course of time the aluminium disintegrates and the solution changes. Disintegration of the aluminium takes place whether an aqueous or a fused electrolyte is used. There are no actual data published concerning use of electrolytic rectifier over a long time. The quality of the aluminium appears to be a factor determining the life of the rectifier.

* * *

A vote of thanks was then adopted to the individuals and companies who, through the many courtesies shown to the society, had made this meeting so successful.

The retiring president, Prof. C. F. Burgess, then introduced the president-elect, Mr. E. G. Acheson, who thanked the society in a few well-chosen words and asked that all members should show their loyalty to the society by attending the meetings and contributing to the *Transactions*. A man's value is not determined by what is in him, but what proceeds from him. An inventor should protect himself as far as patent laws permit, but after he has done so, Mr. Acheson recommends not to be afraid of publicity. "Take the public into your confidence and they will protect you. The public in general is trustworthy and just." He asked the members to contribute accounts not only of their successes or hoped-for successes, but also of their failures. Every experiment must be considered a

success if it only shows what can be done or what cannot be done.

The meeting then adjourned. The next convention will be held about the beginning of October in New York City.

The following is a complete alphabetical list of all members and guests who registered at the meeting:

Edward G. Acheson and Raymond M. Acheson, Niagara Falls, N. Y.; George P. Adamson, Easton, Pa.; Alex. O. Appelberg, Schenectady, N. Y.; Mr. and Mrs. William C. Arsem, Schenectady; W. C. Andrews, Schenectady; L. H. Backeland, Yonkers, N. Y.; Wilder D. Bancroft, Ithaca, N. Y.; H. Barker, New York City; Charles Baskerville, New York City; Frederick M. Becket, Niagara Falls, N. Y.; John W. Beckman, Schenectady; P. McN. Bennie, Niagara Falls, N. Y.; E. J. Berg, Schenectady; E. R. Berry, Lynn, Mass.; Anson G. Betts, Troy, N. Y.; E. Blough, Pittsburg, Pa.; R. W. Boyle, Montreal, Canada; W. C. Bray, Boston, Mass.; George Breed, Philadelphia, Pa.; Howard L. Bronson, Montreal, Canada; J. W. Brown, Cleveland, Ohio; William Hand Browne, Jr., New York City; Charles F. Burgess, Madison, Wis.; Henry S. Carhart, Ann Arbor, Mich.; H. R. Carveth, Niagara Falls, N. Y.; J. A. Capp, Schenectady, N. Y.; T. Parkman Coffin, Schenectady, N. Y.; H. B. Coho, New York City; Edward A. Colby, Newark, N. J.; C. L. Collens, Cleveland, Ohio; Verplanck Colvin, Albany, N. Y.; A. M. Comey, Chester, Pa.; H. R. Connell, Schenectady, N. Y.; Elmer E. F. Creighton, Schenectady; J. S. Crider, Cleveland, Ohio; T. E. Crossman, New York City; Edward Durant, New York; Saul Dushman, Toronto, Canada; Thomas H. Fearey, Canandaigua, N. Y.; Colvin G. Fink, Schenectady, N. Y.; Ad. Fischer, Philadelphia, Pa.; C. M. FitzGerald, New York City; Francis A. J. FitzGerald, Niagara Falls, N. Y.; Richard Fleming, Lynn, Mass.; Charles C. Foster, Rochester, N. Y.; Richard H. Gaines, New York City; W. C. Geer, Akron, Ohio; A. E. Gibbs, Wyandotte, Mich.; Geo. G. Grower, Ansonia, Conn.; Mr. and Mrs. C. A. Hansen, Schenectady, N. Y.; J. L. Hayden, Schenectady; Carl Hering, Philadelphia, Pa.; Henry D. Hibbard, Plainfield, N. J.; Miss H. R. Hosmer, Schenectady; Henry Howard, Brookline, Mass.; Matthew Hunter, Schenectady; W. F. Hurlburt, Newark, N. J.; L. W. Hyman, Albany, N. Y.; Alois von Isakovics, Monticello, N. Y.; D. Forbes Keith, Toronto, Canada; Milton M. Kohn, New York City; S. J. Koshkin, New York City; Irving Langmuir, Hoboken, N. J.; W. M. Legitt, Schenectady; Frank Austin Lidbury, Niagara Falls, N. Y.; A. T. Lincoln, Urbana, Ill.; C. F. Lindsay, Schenectady, N. Y.; Mr. and Mrs. A. B. Marvin, Jr., Schenectady, N. Y.; H. T. Matthew, New York City; Mr. and Mrs. John H. McElroy and James F. McElroy, Albany, N. Y.; D. McIntosh, Montreal, Canada; E. P. McKeefe, Albany, N. Y.; Ralph McNeill, New York City; Max Meyer, New York City; Misses Helen and Mary Miller, Albany, N. Y.; Harlan S. Miner, Gloucester City, N. J.; R. W. Moore, Schenectady, N. Y.; Charles W. Moulton, Schenectady, N. Y.; R. S. Moulton, Schenectady, N. Y.; R. H. Palmer, Schenectady, N. Y.; Charles L. Parsons, Durham, N. H.; Harrison E. Patten, Washington, D. C.; Harold C. Pease, Schenectady, N. Y.; Henry Pikler, Ampere, N. J.; Henry Noel Potter, New York City; Louis C. Raegener, New York City; Miss Margaret Rand, Troy, N. Y.; A. G. Reeve, Niagara Falls, N. Y.; J. W. Richards, South Bethlehem, Pa.; Ralph C. Robinson, Schenectady; Mrs. Samuel Robinson, Boston, Mass.; E. F. Roeber, New York City; W. E. Ruder, Schenectady, N. Y.; Miss M. J. Ruggles, Schenectady, N. Y.; David B. Rushmore, Schenectady; L. E. Saunders, Niagara Falls, N. Y.; L. B. Schleeder, Schenectady, N. Y.; G. P. Scholl, New York City; Clayton H. Sharp, New York City; A. W. Smith, Cleveland, Ohio; S. C. Smith, New York City; A. J. Soper, Montreal, Canada; Charles P. Steinmetz, Schenectady, N. Y.; H. W. Sykes, Syracuse, N. Y.; Mr. and Mrs. Edward R. Taylor and Miss Edith Taylor, Penn Yan, N. Y.; John B. Taylor, Schenectady, N. Y.; M. deK. Thompson, Boston, Mass.; F. J. Tone, Niagara Falls, N. Y.; Willis G. Tucker, Albany, N. Y.; William Valentine, Lansingburgh; A. L. Voge, Zurich, Switzerland; Louis I. Waldman, Albany, N. Y.; Tracy D. Waring, Perth Amboy, N. J.; Oliver P. Watts, Madison, Wis.; Roger C. Wells, Schenectady, N. Y.; R. H. White, Rochester, N. Y.; Mr. and Mrs. Jasper Whiting, Boston, Mass.; W. R. Whitney, Schenectady, N. Y.; Leland M. Willey, Schenectady, N. Y.; Frank A. Wolff, Washington, D. C.; F. C. Zapf, Schenectady, N. Y.; C. Irving Zimmerman, Niagara Falls, N. Y.

Calcium Silicide for the Purification of Metals, Particularly Steel.

By Hans Goldschmidt, Ph.D.

Numerous metals and alloys have been used for a number of years for purifying liquid steel. Among these the best known are manganese, in the form of ferromanganese; silicon, employed in recent years chiefly as high-grade ferrosilicon; also alloys of manganese, silicon and iron. Aluminium has also been a well-known addition, for the reason that it possesses in extraordinary degree the ability to rid liquid steel of the last particles of oxygen or, to use a homely phrase, to "kill" the steel. In this application very small quantities, such as 0.05 per cent., have given satisfactory results.

In spite of its well deserved popularity, this purifying agent (the use of which is necessary in a great many cases) possesses two disadvantages which interfere with its general usefulness; the one might be called a positive, the other a negative property—"negative" in the sense that there is a desirable property which it ought to have, but does not have.

The "positive" quality consists in the fact that the aluminium oxide Al_2O_3 (which is formed during the deoxidation process) remains in appreciable quantities in the steel; in other words, it does not separate out completely into the slag. The cause of this lies in the high melting point of the oxide. It chills already at the temperature of the liquid steel, as the melting point of Al_2O_3, even with some impurities of other metals, is above 1800° C. On polished and etched steel sections these small paticles of Al_2O_3 can be discovered by means of the microscope.

In this connection, it may be of interest to note that titanium also has the property of leaving traces in the steel. On sections of such steel, red crystals of titanium cyanonitride may be observed. This observation also proves that titanium (used in the form of ferrotitanium) has the property of binding nitrogen.[1] The mechanical properties of the steel, however, are somewhat interfered with by these small non-metallic impurities.

What I call above the "negative quality" of aluminium is the fact that it is unable to bind any sulphur that may be present in the steel. It is just in this respect that calcium silicide shows to advantage as a purifier. It has the special property to reduce the last traces of sulphur, the elimination of which is often of the highest importance in the manufacture of special steels.

The difficulties of producing a steel with a maximum of 0.02 per cent. sulphur are well known. Specifications—particularly of the government—often call for that amount as a maximum. One can then take a steel with 0.04 to 0.06 per cent. sulphur, add the calcium silicide and thereby reduce the sulphur to the allowable proportion. In doing so, calcium sulphide is formed, while the silicon is mostly oxidized and combines with the oxides present to a highly liquid slag. This slag remains liquid quite as long as the steel and therefore finds it easy to rise to the surface and the impurities (such as are present with the aluminium) disappear as a result of the treatment with the calcium silicide.

Silicide of calcium represents, therefore, an entirely new and effective purifying agent, which is used exactly like aluminium.

The calcium silicide employed in practice contains about 30 per cent. calcium, the remainder being principally silicon. As impurities, a few percentages of iron are present. An important point in its application is that it is technically free from carbon. In appearance it resembles silicon, being coarsely crystalline, very brittle and remaining unaffected by the influence of the atmosphere. A definite formula for its use can, of course, not be given, being controlled by the peculiarities in the composition of the steel which is to be purified. A series of tests with analyses will quickly instruct the steel maker.

The introduction of this method was only begun during the first months of this year, after the subject had been studied for a long time. In Germany it has received considerable attention and large quantities of steel have already been refined by this process, while nearly all large steel works are now making tests with it.

A further field that promises much is the refining of nickel, copper or bronze castings with calcium silicide. Its mission is, of course, not to drive out the aluminium, but only to complete the series of purifying agents by enabling certain kinds of steel to be improved in a simple and quick manner.

Society of Chemical Industry.

At the meeting of the New York section of the Society of Chemical Industry, held on April 16, Dr. Roland Calberla, of the chemical department of Columbia University, gave an account of laboratory experiments on the production of ferrochrome in the electric furnace. Dr. Wm. J. Schieffelin then described an interesting process of making lithia from lepidolite; as a result of the drop in the price of lithia the process is, however, no longer in use. Prof. William Hallock, of Columbia University, finally presented an informal, but very interesting experimental lecture on "a new gas for illuminating, heating and power purposes," discussing the possibilities of Blau gas, which is now being introduced in this country, especially for train lighting.

[1] Practical experience proves that ferrotitanium is not suitable for alloying if the titanium is present in a larger percentage than 20 to 25. Higher percentages resist alloying with liquid steel.

The Tank House and Copper Furnaces of the New Addition to the Raritan Copper Works

BY FRANK D. EASTERBROOKS.

Tank House.—This building, in which the copper bullion is electrolytically refined, is 149.5 ft. wide and 584 ft. long. The skeleton frame contains approximately 500 tons of steel and rests on heavy concrete foundation walls, while the 12-in. brick walls were built without pilasters, except on the ends under the crane runways, the steel frame carrying the main loads.

The building is divided into three bays running lengthwise of the building with two 10-ton three-motor Whiting cranes

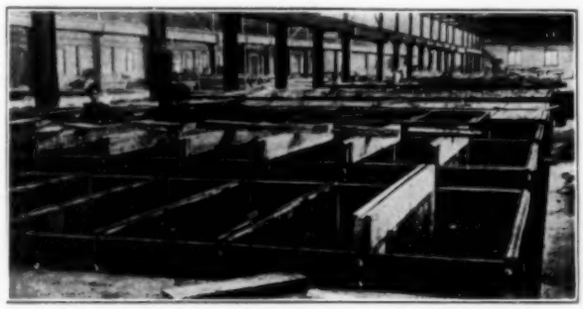


FIG. 1.—TANKS DURING CONSTRUCTION.

in each bay, which are equipped with a special device with fixed guides, for handling a tank full of anodes or cathodes at one time.

The following table contains data relating to these cranes:

	Make of motor	Horse-power of motor	Speed of motor r.p.m.	Travel of crane ft. per min.
Trolley	Westinghouse	4	690	175
Bridge	"	26	640	350
Hoist	"	40	575	40

A clearance of 19 ft. 8 in. in the two outside bays and 31 ft. in the center bay between the floor and the bottom chord of

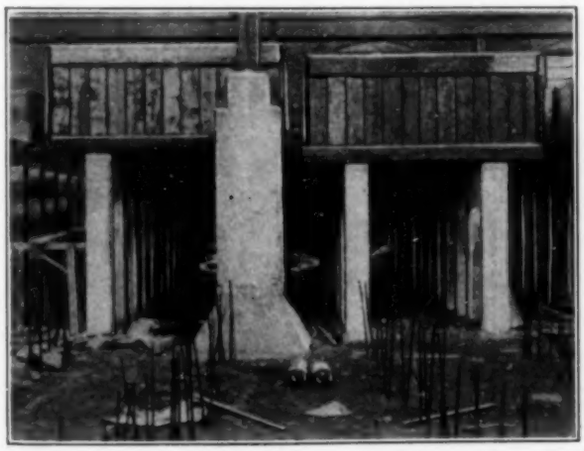


FIG. 2.—VIEW OF TANKS FROM BASEMENT.

the roof trusses, together with a great number of windows and the large monitor which runs the full length of the building, makes the tank room extremely well lighted and ventilated; in addition, a heating system installed by the New York Blower Company completely changes the air in the building every hour. The roof planking is covered with a 5-ply tar and gravel roof.

Basement.—Special attention was given to the construction of the basement. Areaways were built entirely around the building, with numerous windows in the concrete foundation walls, and the whole inside was covered with two coats of whitewash, which gives a well-lighted interior requiring no artificial illumination.

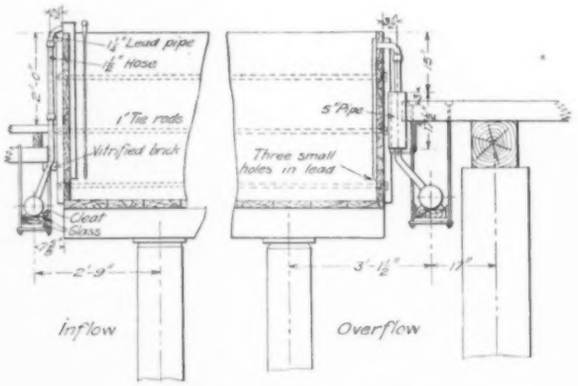


FIG. 3.—DETAILS OF CIRCULATION.

For the basement floor, it was decided that bricks laid on top of a concrete bed with the joints filled with pitch would be the most durable, provided a brick could be obtained which was unaffected by the sulphuric acid solution. To this end some 20 to 25 different makes of bricks were tested for a considerable length of time, with the result that the Berlin brick manufactured by the New York Brick & Paving Company, which was used, was found to be acid proof. The whole floor is drained toward three lead-lined sumps.

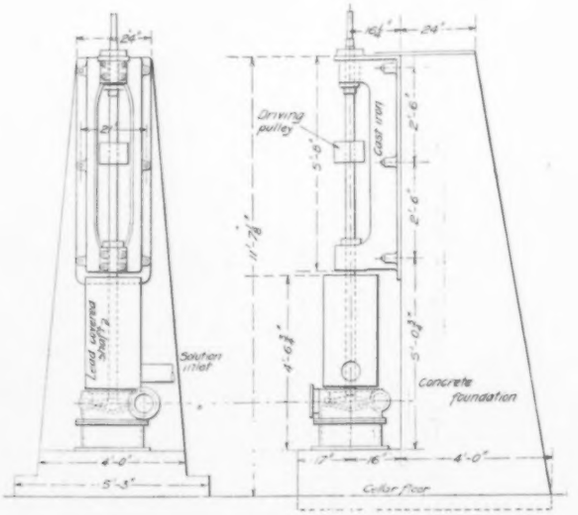


FIG. 4.—HARD LEAD CIRCULATING PUMP.

The light, airy cellar and the large head room, 9 ft. 9 in. between top of basement floor and top of main floor, are of great assistance in detecting quickly any leaks and runovers, while the acid-proof floor prevents loss from solution leaks or accidental spilling of slimes, losses from these two causes being greater even in well regulated plants than is generally supposed.

Three concrete tunnels connect the power house with the tank house basement. This building with its light basement, acid-proof floor and airy main floor, together with the ventilating and heating system, is, so far as the writer knows, the best adapted for the work of any yet built, and should

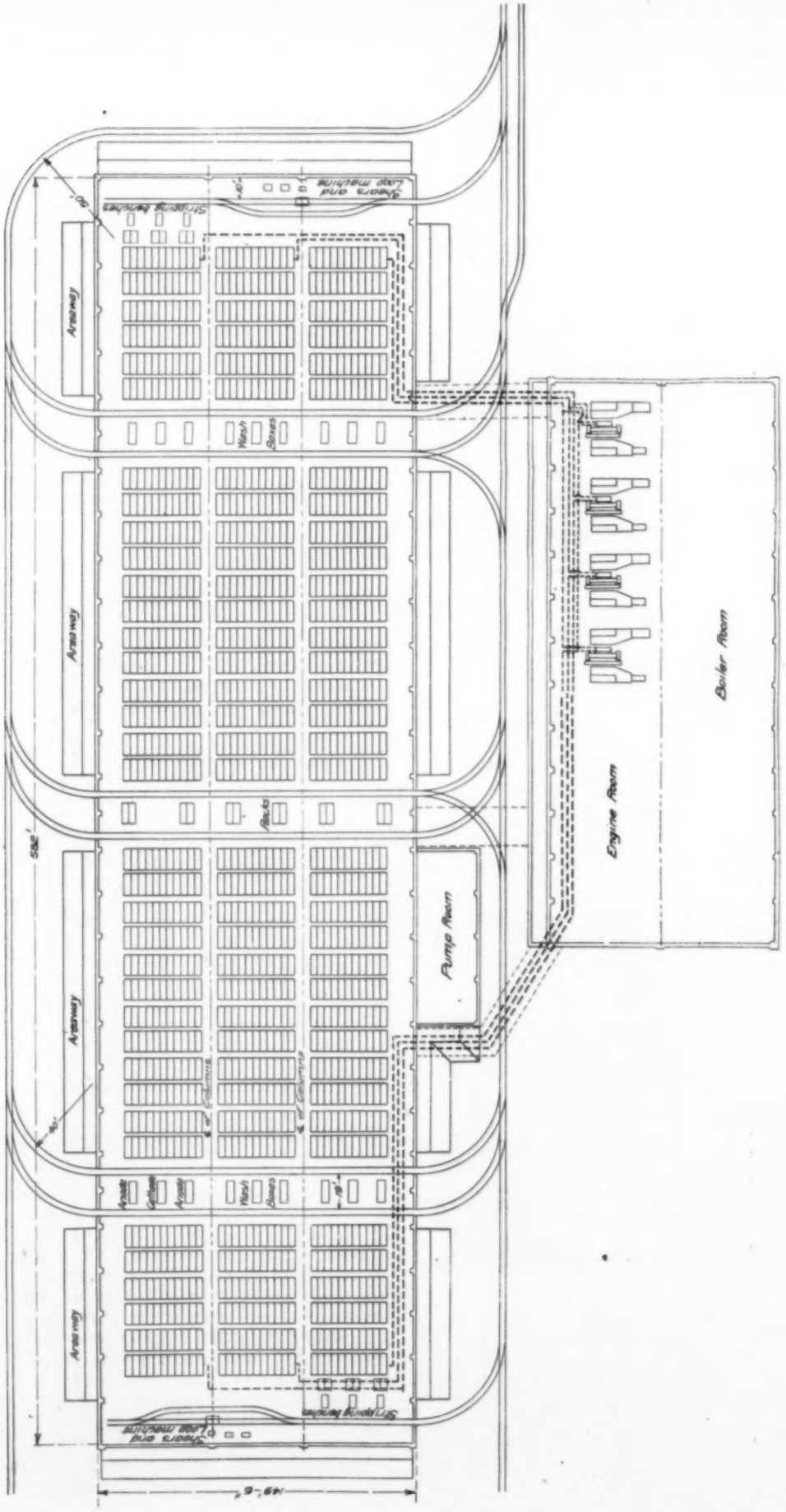


FIG. 5.—PLAN OF TANK HOUSE.

prove of some assistance to the operating department in that which is really the ultimate aim of all industrial establishments, the reduction of operating costs.

General Arrangement.—There are 1188 depositing tanks in the building, arranged in 108 nests of 11 cells each. Two nests of 11 cells each are placed together so as to circulate the electrolyte in cascade through two tanks. The tanks were constructed according to the Walker arrangement (U. S. Patent No. 687,800), which is now in general use at the electrolytic copper refining plants of the American Smelting & Refining Company, Maurer, N. J.; The U. S. Metals Refining Company, at Chrome, N. J., and The Mountain Copper Company at Martinez, California.

The large amount of current used requires for its economical transmission a busbar of large cross-sectional area. With the size adopted, 12¾ sq. in., the difference in the amount of copper tied up in busbars and connections between the arrangement in use in the No. 1 tank house (for a description of which arrangement see Mineral Industry, Volume IX, 1901, page 269) and the Walker arrangement amounted to between 450,000 and 500,000 lb. in favor of the latter.

A heavy glass plate 12 in. square, placed on top of the concrete piers which were constructed to support the tanks, serves to insulate them from the ground. See Fig. 5 for general arrangement of tank house and Fig. 6 for detail of tank construction.

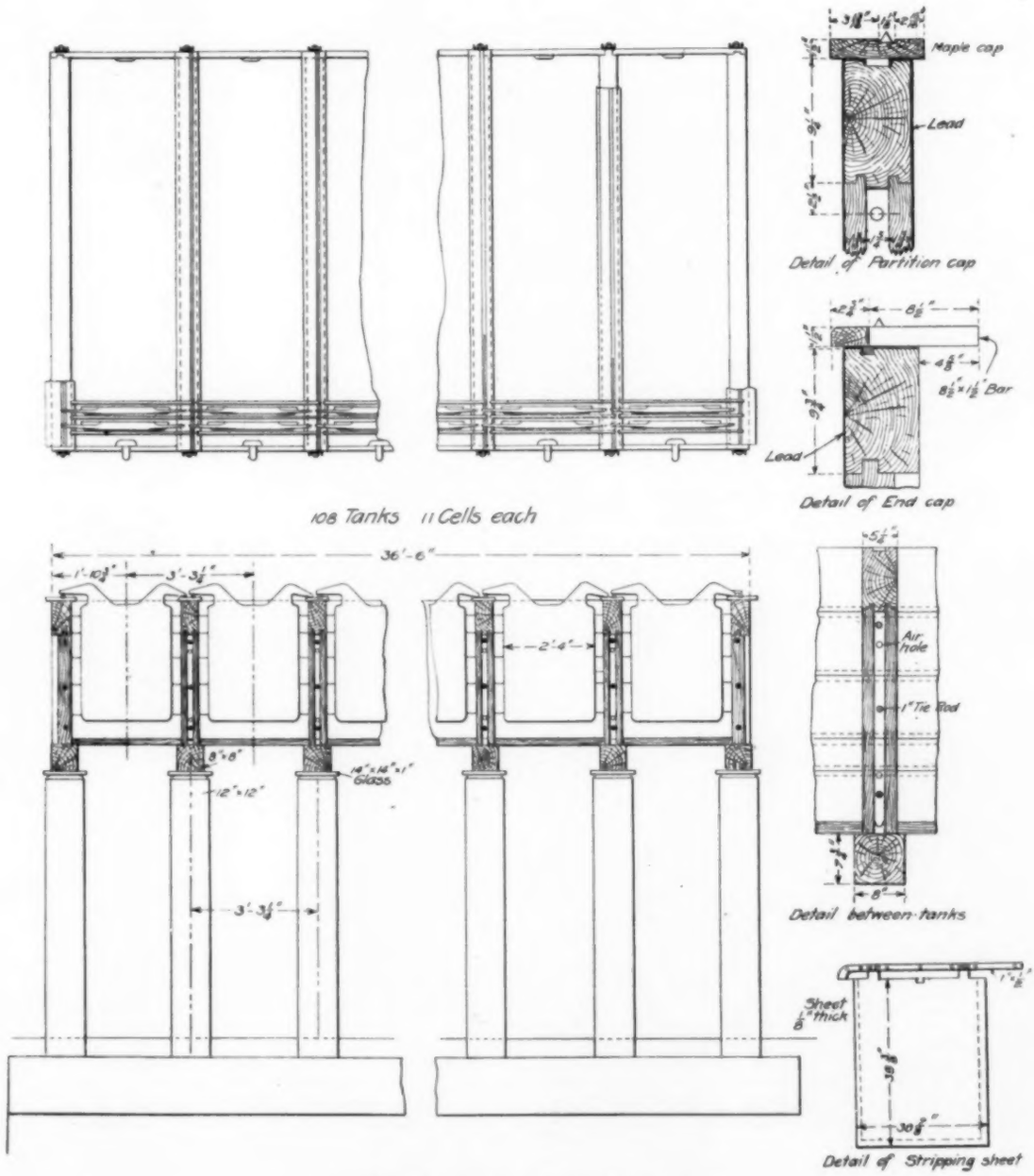


FIG. 6.—DETAILS OF TANK CONSTRUCTION.

At diagonally opposite ends of the building are located the shears for trimming cathode loops, and the Morrow loop machine (U. S. Patent 600,498) for attaching copper loops to the cathode starting sheets.

Special tanks for rinsing the electrolyte from the cathodes, after being removed from the depositing tanks and before loading on cars, are located in the main aisles, as are also the tanks for scrubbing the slimes from the scrap anodes, before returning them to the anode furnaces.

Tank Details.—Each tank contains 24 anodes and 25 cathodes, spaced on 4⅝ in. centers. The anodes are 28 in. wide by 36 in. long, while the cathodes are about 30 in. wide

by 37 in. long, giving an active cathode service per tank of approximately 369.5 sq. ft. With a current of 7500 amperes this gives a current density of 20 amperes per square foot.

The tank room is divided into three circuits running lengthwise of the building, one in each bay. Each circuit of 396

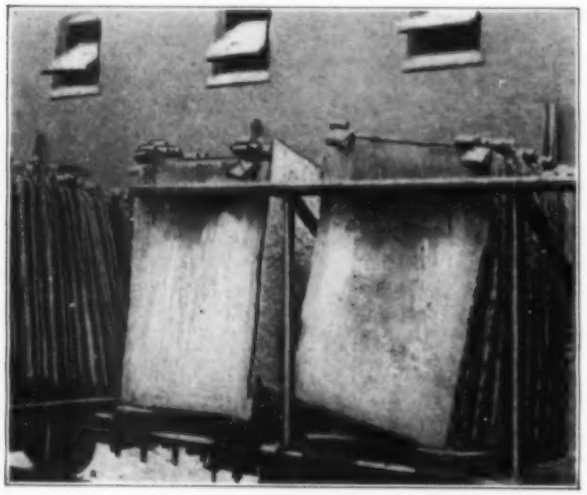


FIG. 7.—METHOD OF LOADING CATHODES.

tanks forms a load for one of the electrolytic generators in the power house.

The main conductor bars have a cross sectional area of 12.75 sq. in., but busbars at each end of the nests of tanks are proportioned so as to reduce the amount of copper held permanently in plant, only that portion carrying the full current between two nests of tanks having the full area. That surface of the bars forming contacts with the anodes and cathodes is of triangular shape, making a knife edge contact

FIG. 8.—LINING TANKS WITH LEAD.

which is more easily kept clean than a flat bar. The tanks are lined with 6-lb. lead containing 4 per cent antimony.

Circulation of Electrolyte.—The general direction of the electrolytic circuits is lengthwise of the tank house, while the circulation of the electrolyte is crosswise. For circulation purposes the tank house is divided into 6 units of 198 tanks each. The rate of circulation is about four gallons of solution per tank per minute. The solution enters at the bottom of each tank and overflows, as shown in Fig. 3, overflowing in greater part from the top, while a smaller portion of the heavier solutions is taken from the bottom of each tank.

The hard-lead centrifugal pumps for circulating the electrolyte are located in a building on the south side of the tank room, and are of a special design which was worked out at this plant. See Fig. 4 for the general arrangement of the pump, the chief feature of which is that there are no stuffing boxes or wearing parts in contact with the solution, the shaft bearings being placed above the level of the inflowing solution. This pump has solved the problem of an entirely satisfactory method for circulating a hot sulphuric acid solution, and while the efficiency is good, reliability and low operating costs were the main features considered.

For maintaining the copper contents of the electrolyte at a fixed quantity, the copper anodes in a regular depositing tank are replaced by lead ones. The simple expedient of placing a heavy oil on top of the solution in these tanks, with precautions to prevent its running off, prevents the gases from contaminating the air.

When slimes are to be removed from the tanks the circulation is stopped and the current shunted from two nests of tanks. The slimes, after being screened and flushed through launders to a sump, are pumped to the slime receiving tanks

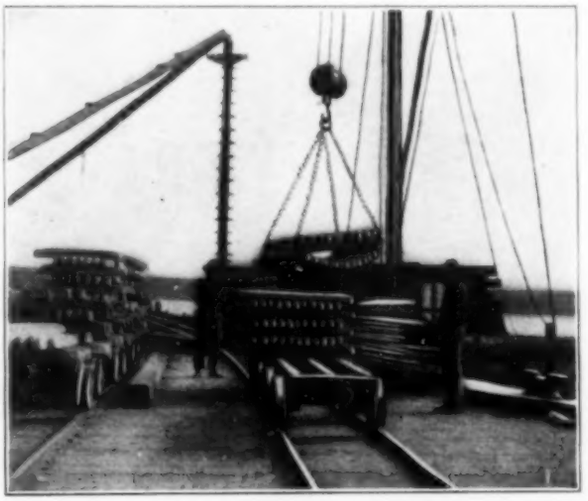


FIG. 9.—LOADING WIRE BARS FOR SHIPMENT.

in the silver refinery by means of a small hard-lead centrifugal pump of the same design as the circulating pumps.

Starting Sheet Tanks —The "stripping" tanks are located at diagonally opposite ends of the tank room. The heavy rolled copper plate on which the starting sheet is formed has the rod from which it is hung riveted to it. (See Fig. 6). A small V-shaped groove cut in around the outside edges of the sheet does away with the necessity of using wooden strips in order to obtain satisfactory starting sheets (McCoy Patent No. 684,291, and Elliot and Kitchner Patent No. 683,263).

A thin coating of rack grease rubbed over the stripping plate serves to prevent the deposited sheet from firmly adhering to the plate. The stripping of these starting sheets, which is done on benches located in the end aisles next to the tanks, is a laborious operation, and of course any increase in the size of the cathode sheets renders this operation more difficult.

The production of good, sound starting sheets is a fundamental in tank-house operation. The sheets as stripped from the plates are thrown onto small cars, rolled across the building to the machines, where two copper loops are riveted on, and, after being beaten out smooth, are hung in the tanks from round copper rods flattened at one end.

The cathodes are removed from the tanks by the crane, a tank full at a time, and after rinsing in warm water to remove the copper sulphate solution, are unloaded in an upright position directly onto specially constructed cars (see Fig. 7) without any handling except that necessary to remove the rods from the loops.

The anodes (the size of which was increased over that in use in No. 1 tank house) are brought into the building on steel cars and placed in steel racks in the same relative position that they will occupy in the tanks. They are put in the tanks by the crane, a tankful at a time. As the labor cost in the

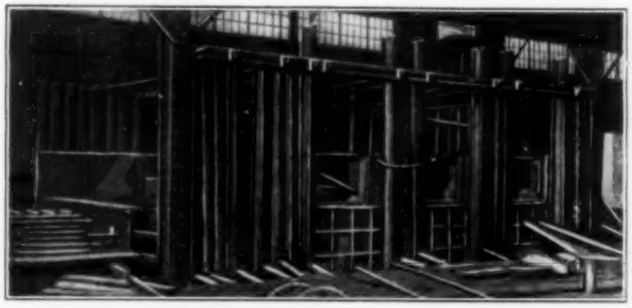


FIG. 10.—VIEW OF WIRE BAR FURNACE.

tank room depends on the number rather than the weight of the electrodes handled, any increase in the weight and size of the individual pieces will effect a reduction in the unit labor cost per ton of copper refined.

The cathodes remain in the tanks 14 days before being removed; the anodes 28 days, when they are taken out, washed clean of slimes and sent to the anode furnaces to be recast into anodes. In actual practice this scrap amounts to about 13 per cent of the total weight of copper treated, or expressed in another form, 13 per cent of all the copper refined is held in process of treatment for a further period of several days in order to be case into anodes, sampled and weighed. It is then placed in the depositing tanks for another period of 28 days.

The above also holds true for the gold and silver contents of the copper, 13 per cent of the total values treated being delayed for a corresponding period of time before they are transferred to the silver refinery.

In operating the tank house, a working schedule is first made out. As the anodes remain in the tanks 28 days, each tank must be cleaned once in that time. The day's work is divided equally among the three circuits, care being taken also that the tanks cleaned shall be divided equally among the different circulations, on account of the storage required for the solution removed from the tanks.

In the following table is given the approximate amount of refined copper required to construct and operate the tank house. The copper wire necessary to connect up the various motors, or the Cooper Hewitt mercury-vapor lamps with which the tank house is lighted by night, are not included.

Copper cathode rods	186,000 lb.
Stripping plates	122,000 "
Lead anode rods	3,000 "
Busbars, connections, etc	170,000 "
Leads, etc	100,000 "
Total	581,000 lb.

It may be of interest to note that the amount of copper held in the tanks at any one time in process of treatment amounts to between 11,000,000 and 12,000,000 lb., while the amount held in solution in the electrolyte is approximately 240,000 lbs. The amount of lead used in constructing the tank house was about as follows:

Lining tanks, etc	1,050,000 lb.
Pipe for solution, overflows, etc	180,000 "
Pump room, lead anodes, etc	140,000 "
Total	1,370,000 lb.

In the following table are given some of the principal features of the No. 1 and No. 2 tank houses.

	No. 1 Tank House	No. 2 Tank House
Total number of depositing tanks	1,600	1,188
Anodes per tank	21	24
Cathodes per tank	21	25
Size of anodes	2′ x 3′	2′ 4″ x 3′
Size of cathodes	2′ x 3′	2′ 6″ x 3′ 1″
Sq. ft. cathode surface per tank	252	369.5
Current in amperes	5,000	7,500
Current density in amperes per sq. ft. cathode surface	19.8	20.
Number of circulations	4	6
Cross-sectional area of busbars in sq. in.	5	12¾
Number of tanks in cascade	5	2
Number of circuits	5	3
Anodes, number days corroding	35	28
Supports for tanks	timber	concrete

Anode Furnaces.—No new furnaces were built for casting anodes from pig copper, as the material refined in the No. 2 tank house is received already cast in that shape. Two of the original anode furnaces were, however, enlarged, increasing their capacity to 200,000 lb. daily. The anodes are cast in iron molds on a mechanical conveyor, from which they are loaded on to skeleton frame steel cars of heavy construction by means of an air hoist. The molds in which the copper is cast are made in two pieces clamped together according to the Antisell patent (U. S. Patent No. 867,694), which greatly increases the life of the molds.

The coal used in the wire bar and anode furnaces is brought from the coal trestle in electric cars. An elevator which was furnished by the Albro-Clemm Company and located just outside the No. 1 furnace building raises these cars to tracks which run the length of both furnace buildings and which are supported by the roof trusses. Hoppers located so that the coal is delivered in front of the fire-box door receive the coal from these cars.

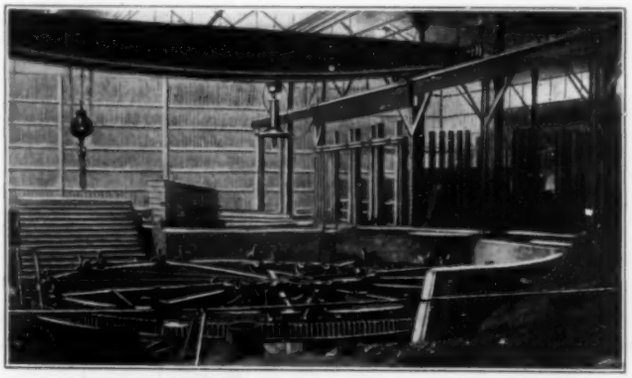


FIG. 11.—WIRE BAR CASTING APPARATUS.

Wire Bar Furnaces.—For casting the cathodes into wire bars and ingots, two new furnaces, each of 150 tons capacity, were constructed in the No. 2 furnace building. These furnaces have a hearth 33 ft. 6 in. by 16 ft. 9 in., with an area of 470 sq. ft. The fire box is 8 ft. by 10 ft., giving a ratio of 1 to 6 between the area of the fire box and that of the hearth. The foundation and piers are entirely of concrete construction.

In order to reduce the time of charging such a large quantity of cathodes, doors were constructed on each side of the furnace, two on one and three on the other side, thus permitting of charging crews working from both sides of the furnace at the same time. The roof of the furnace was constructed of 13½-in. brick. The bottom is made up of 18 in. of sand on 9 in. of silica brick, resting on the 1¾-in. iron plates, which are carried by the concrete piers. The conker

plates and the iron castings over the charging doors are water cooled. The gases pass through a short flue to the 6-ft. brick-lined iron flue 100 ft. in height, which is located just outside the building, the intention being to install waste heat boilers at a later date, taking the gases from the flue close to the furnace.

For casting the copper from these two furnaces two casting machines of a new design (Clark patent, U. S., No. 818,076) were constructed. These machines consist essentially of two parts, the wheel proper on which the copper molds are carried, and the conveyor which raises the bars from the bosh. Fig. 11 shows a general view of the wheel and conveyor during construction.

The wheel is made up of a series of I-beam arms fastened at the circumference to a heavy iron casting, the outside of which forms the rack by means of which the wheel is revolved. The diameter of the wheel is 36 ft. The double copper molds are attached parallel with the I-beam arms, one on each side, so that the stream of copper as it is poured from the ladle flows lengthwise of the mold, four bars being cast at one time.

An automatic arrangement allows the bars to be dumped from the molds when directly over the bosh, while a self-righting device returns the mold to an upright position just before reaching the ladle.

The copper when tapped from the furnace flows through a launder, 6 ft. 6 in. long, to a large ladle and thence into the molds. This ladle is raised and lowered by a hydraulic lift, the operator controlling with one hand, by means of a three-way valve, the tilting of the ladle, while with the other hand the rotation of the wheel is regulated by means of the regular controller. The bars, after being dumped, are taken from the bosh by a conveyor which is constructed of steel channel irons carried on an endless chain of link work. This conveyor is driven by a separate motor.

When casting copper, water is circulated through the bosh by means of a 14-in. centrifugal pump driven by a Ball & Wood horizontal tandem compound engine located in the No. 1 power house. In order to reduce the amount of water used, which is an important feature where such large quantities of copper are being cast, a reservoir was constructed where it could be pumped back and cooled by spraying through air before being returned to the boshes.

Metallurgical Calculations.

By J. W. Richards,
Professor in Metallurgy in Lehigh University.

The Metallurgy of Zinc—III.

The condensation of zinc from the state of vapor follows the same laws as regulate the condensing of all gases. If it is by itself in a cooler space, it condenses by contact with the walls as finely divided zinc dust (blue powder) if the walls are cold, as liquid zinc if the walls are hot, and it keeps on condensing until the tension of the remaining vapor is equal to the maximum tension of zinc vapor at the temperature of the condensing vessel. This condition having been reached, no more will condense until the condenser is cooled. At any temperature, therefore an amount of zinc remains uncondensed corresponding to the maximum vapor tension of zinc at that temperature.

If other indifferent gases are present, the zinc vapor sustains only part of the atmospheric pressure, or pressure on the whole mixture, so that condensation cannot begin until a lower temperature is reached; that is, a temperature at which the maximum vapor tension of the zinc equals its partial vapor tension in the gas mixture. At this point condensation begins and continues as the temperature falls, the gas mixture always being saturated with zinc vapor. The phenomenon is precisely similar to the production of rain by the cooling of air containing moisture.

As to what the vapor tension of zinc is, the data are scanty. The boiling point under atmospheric pressure is 930° C., where its vapor tension is 760 m.m. of mercury column. According to Barus, the maximum tension increases 6.67 m.m. for each 1° C. increase of temperature. This is a difficult determination, but corresponds satisfactorily with the calculated increase from analogy to water and mercury.

Water, boiling at 100° C. (273° absolute), varies 1° in boiling point for 27.20 m.m. variation in vapor tension; mercury, boiling at 357° C. (630° absolute) varies 1° in boiling point for 12.66 m.m. variation in vapor tension. The ratio of the two variations is seen to be practically the inverse ratio of the two boiling points.

$$\frac{630}{273} = 2.3 \qquad \frac{27.20}{12.66} = 2.2$$

If we compare mercury with zinc, with the two boiling points 357° and 930° (630° and 1203° absolute), and the observed variations in vapor tension at the normal boiling point of 12.66 m.m. and 6.67 m.m. per 1° rise in boiling temperature, the two ratios are

$$\frac{1203}{630} = 1.91 \qquad \frac{12.66}{6.67} = 1.90$$

This coincidence justifies us completely in assuming that the vapor tension curve of zinc may be calculated directly from that of mercury, by assigning for any given vapor tension an absolute temperature to the zinc vapor of 1.91 times that of mercury vapor. For cadmium we may use the similar ratio of the normal boiling points in absolute degrees:

$$\frac{273 + 780}{273 + 357} = \frac{1053}{630} = 1.67$$

and thus calculate the cadmium curve from the mercury curve.

From incipient vaporization to ebullition in a vacuum.

Tension of vapor m.m. of Hg.	Mercury C°.	Cadmium C°.	Zinc C°.
0.0002	0	183	248
0.0005	10	200	267
0.0013	20	216	286
0.0029	30	233	305
0.0063	40	250	324
0.013	50	267	344
0.026	60	283	363
0.050	70	300	382
0.093	80	317	401
0.165	90	333	420
0.285	100	350	439
0.478	110	367	458
0.779	120	383	477
1.24	130	400	496
1.93	140	417	516
2.93	150	433	535
4.38	160	450	554
6.41	170	467	573
9.23	180	483	592

Before proceeding further, we would remark that cadmium melts at 320° and zinc at 419°; that both can, therefore, show vaporizing phenomena nearly 150° below their melting points. At 9 m.m. tension, 180° C., mercury begins to show the phenomena of ebullition, and we would, therefore, expect cadmium to "simmer" at 483° and zinc at 592°. Neither of these observations have as yet been experimentally investigated, so far as the author knows.

From ebullition in vacuum to normal boiling point.

Tension of vapor m.m. of Hg.	Mercury C°.	Cadmium C°.	Zinc C°.
9.23	180	483	592
14.84	190	500	611
19.90	200	517	630
26.35	210	533	649
34.70	220	550	668

45.35	230	567	687
58.82	240	584	706
75.75	250	600	726
96.73	260	617	745
123.	270	634	764
155.	280	650	783
195.	290	667	802
242.	300	684	821
300.	310	700	840
369.	320	717	859
451.	330	734	878
548.	340	750	897
663.	350	767	915
760.	357	780	930

The above table contains the more important data for the actual condensation of zinc, cadmium and mercury vapors in practice. Thus, if a mixture of zinc or cadmium vapor with an equal volume of indifferent gas goes into a condenser, the partial pressure of the metallic vapor being in this case only half an atmosphere, or 380 m.m., no metal will commence to condense until the temperature of the gases is reduced to 862° for zinc and 720° for cadmium. If mercury vapor from a roaster is mixed with 19 times its volume of other gas, so that it only forms 5 per cent of the mixture, its partial tension will be only 5 per cent of 760 m.m. = 38 m.m., and no mercury will commence to condense until the temperature of the gas mixture is reduced to 224°. These temperatures are exactly analogous to the phenomenon of the dew point of moist air, the temperature at which rain forms.

From normal boiling point to high pressures.

Tension of vapor atmospheres.	Mercury C°.	Cadmium C°.	Zinc C°.
1.0	357	780	930
2.1	400	851	1012
4.25	450	934	1107
8.	500	1018	1203
13.8	550	1101	1298
22.3	600	1185	1394
34.0	650	1268	1489
50.	700	1352	1585
72.	750	1435	1680
102.	800	1519	1776
137.5	850	1602	1871
162.	880	1652	1928

The latter table may have several special applications. If zinc, for instance, were placed in a closed electric furnace filled with indifferent gas and capable of supporting 100 atmospheres pressure, zinc could be kept in the liquid state up to some 1700° C., and its alloying with other metals greatly facilitated. In the making of brass, for instance, much zinc is lost by volatilization at the melting point of the copper used, yet a pressure on the furnace of four atmospheres would entirely prevent loss of zinc at the melting point of copper. Induction electric furnaces could easily be run inside a pressure vessel at this temperature, and the pressure be relieved gradually as the temperature of the melted alloy was reduced. To keep zinc from boiling, or to keep it in the liquid state, at 1300°, not a high temperature, would require a pressure of nearly 14 atmospheres to prevent it from boiling *ad libitum*.

Problem 134.

Roasted zinc sulphide ore, consisting practically of pure ZnO, is reduced by carbon, and the reduction gases passed into a condenser. Assume the reaction to be

$$ZnO + C = Zn + CO.$$

Required:

(1) The temperature at which zinc commences to condense from the above gas mixture.

(2) The proportion of the zinc condensed out for each 1° reduction of temperature below this "dew point."

(3) The proportion of the zinc escaping uncondensed, if the gas escapes from the condenser at 600° C.

(4) How would these data be affected, if the reduction was taking place at Denver, 1500 meters above sea level, barometer 560 m.m.?

Solution:

(1) Since zinc vapor has been shown to have a specific gravity of 32.5 referred to hydrogen gas at the same temperature and pressure, and the molecular weight of hydrogen gas, formula H^2, is 2, the molecular weight of zinc vapor must be $2 \times 32.5 = 65$. This coincides with the atomic weight of zinc, and therefore zinc vapor is monatomic and the symbol of its molecule is Zn. The gas mixture in the above equation contains, therefore, one molecule each of its two constituents, and, therefore, each gas supports half the atmospheric pressure. This is ordinarily expressed by saying that the gas is half one constituent and half the other, meaning that if the two gases were separated and each measured under the prevailing normal pressure, the volume of each would be half the volume of the gas mixture. The statement that each supports half the normal pressure is the more scientific and logical, for in a gas mixture each gas certainly possesses the volume of the mixture, but under only a fraction of the pressure on the mixture, said fraction being identical with the fraction of the volume of the whole which it would constitute, if measured separately under the pressure supported by the mixture.

Consulting the table, we find zinc vapor to have a pressure of 380 m.m. at **862°**. This would, therefore, be the dew point, at which the zinc would commence to condense.

(2) At this condensing temperature, a difference of 19° in the temperature corresponds to 82 m.m. difference in the maximum vapor tension, and, therefore, in this gas mixture at this temperature, a reduction of 1° in its temperature will reduce the tension of the zinc vapor $82 \div 19 = 4.3$, or practically 4 m.m. This will result in the condensation of $\frac{4}{380}$ths. of the zinc, because its tension was 380 and was reduced to 376, and, therefore, $\frac{376}{380}$ths. of it remained uncondensed. The proportion condensed for the reduction of 1° in temperature is, therefore, a trifle over **1** per cent.

(3) Leaving the condenser at 600°, the tension of the zinc vapor escaping would be, from the table, 11.6 m.m. The tension of the CO gas would, therefore, be $760 - 11.6 = 748.4$ m.m. For every cubic meter of mixed gases, at 862°, containing a cubic meter of zinc vapor at that temperature and 380 m.m. pressure, there will escape a fraction of a cubic meter of mixed gas at 600°, containing zinc vapor at 11.6 m.m. pressure. The fractional volume can be calculated from the tension on the CO.

1 m^3 CO at 862° and 380 m.m. pressure, reduced to 600° and 748.4 m.m. pressure, becomes

$$1 \times \frac{600 + 273}{862 + 273} \times \frac{380}{748.4} = 0.381 \text{ m}^3.$$

This is, then, the actual volume of gas mixture escaping, for each actual 1 m^3 of gas mixture in the condenser at the "dew point," 862°.

The uncondensed zinc vapor is, therefore, 0.381 m^3 at 600° and 11.6 m.m. tension. This would be, at 862° and 380 m.m. tension

$$0.381 \times \frac{862 + 273}{600 + 273} \times \frac{11.6}{380} = 0.015 \text{ m}^3.$$

There, therefore, escaped uncondensed

$$\frac{0.015}{1.000} = 0.015 = \mathbf{1.5} \text{ per cent of the zinc.} \qquad (3)$$

A quicker solution, not so easy to understand, however, is

$$\frac{11.6}{748.4} = 0.015 = \mathbf{1.5} \text{ per cent uncondensed.}$$

(4) If the operation takes place at such elevation above sea-level that the barometer stands normally at 560 m.m., then the partial pressure of the zinc vapor in above case would be 280

m.m. instead of 380 m.m., and the "dew point" or temperature at which condensation commences would be 835° instead of 862°, as under previous conditions.

At this temperature, a difference of 1° in the temperature corresponds to a difference of 3 m.m. in the tension of the zinc vapor, producing therefore a condensation of the zinc present, per 1° fall of temperature, of $3 \div 280 = 0.011 = 1.1$ per cent, instead of 1.2 per cent.

If the temperature of the escaping gases is 600°, with the saturated zinc vapor at 11.8 m.m. tension and the carbonous oxide, CO, at $560 - 11.8 = 548.2$ m.m., the proportion of the original quantity of zinc escaping uncondensed is $11.8 \div 548.2 = 0.022 = 2.2$ per cent, instead of 1.5 per cent.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

Institution of Mining and Metallurgy.

Metallurgy of Gold.—Mr. Alfred James, in his presidential address, read at the annual meeting on April 2, presented a concise sketch of the advances made in the treatment of gold-bearing material during the last twenty years. He said that in the earlier portion of this period British or American technical literature contained hardly any noteworthy reference to problems of gold mining or milling. The rough-and-ready method of doing things then had now given place to scientific accuracy; and one result of the consequent progress has been to place on a sound commercial basis the winning of gold from ores already developed or opened out, and investments in certain established gold mines were found in the troublous times of a year or two ago to have depreciated less in value than our own government consols. This great advance was rendered possible by the superior training and attainments of the engineers in charge, as well as by the foresight and enterprise of the great firms and corporations which controlled them. Small 10-stamp propositions have developed to huge undertakings running 200 stamps or more; managers were required of wider and more scientific training than many of our mining-foreman friends of twenty years ago had; and, the requisite number of highly trained men not being available in this country, a demand arose for assistance from our American *confrères*.

It is impossible to survey the history of the past twenty years without bearing witness to the extraordinary effect of the keenness, energy and ability of our transatlantic brethren, so many of whom we are proud to number among our members. The old sources could supply the type of man required, but not in sufficient numbers, and the best among the Old World men have not merely held their ground, but have actually gained by their being pitted against the methods and practice of the new school. But in the training of our new men we are again indebted to, among others, our American brethren who have pointed out how our methods of technical training differ from theirs; and thus it has come to pass that the graduate of 1908 is a much more practical and practicable product than was his predecessor of 1888. His holiday practical schools and post-graduate courses have inspired him with a keenness to get at the bottom of things first-hand; and he can now adjust and apply his theory to practical operations in a way attainable previously only after much, oftentimes, painful experience. The contrast of the twenty years is also seen in the methods employed. Then, electric winches, motors, pumps and signals were practically unknown, and the use of electrical appliances underground had not been generally developed. Improvements effected in hoisting had rendered possible the raising of upwards of 2,000 tons per day through one shaft, and underground sanitation has been considerably advanced.

But it is in the treatment of gold ores that, possibly the greatest evidence is found of the progress of the last twenty years. In 1888 the number of gold mines not employing assayers was considerable, and even one gold metallurgist on the local staff was, indeed, a rarity, but the new metallurgy of gold ores and the technical skill required have changed all this, and the adviser is now no longer merely troubled about the best methods of treating an ore, but also, and even more so, as to the methods most suitable to the skill and intelligence of the local technical staff. Filter presses were at first reported failures, yet greater experience caused the condemned failures to be hailed as great successes.

The following improvements in treatment methods are worthy of notice: The sorting of waste rock from reef matter to be milled; the use of separate crushing stations with high-capacity crushers; the general adoption of mechanical transport for the ore; the provision of storage bins of great capacity; the provision of special water supply, usually with its acidity neutralized, for the mill; the use of heavy stamps; the use of long, unbroken plates for mill amalgamation and of shaking plates for forced amalgamation after tube mills; the adoption of regrinding appliances, such as pans and tube-mills, although the economy of tube mills is doubtful; the provision of automatic weighing and sampling devices; the introduction of the cyanide process for treating sands and slimes, which has now been generally adopted, even at chlorination works; the use of improved mechanical roasting furnaces making refractory ores (sulphide, arsenical, telluride and even antimonial) amenable to the cyanide or chlorination processes; and the provision of tailing wheels or other suitable means for elevating pulp.

The adoption of the cyanide process has brought about such improvements as separation of sands and slimes; the direct filling of sand-vats without preliminary settlement; the use of spitzkasten and conical vats resulting in great saving of water and the abolition of tailing dams; the use of belt conveyors for residues; and the use of the decantation filter press and other methods for recovery of gold from slimes.

As the period covered by these remarks is coincident with the existence of the cyanide process, it is interesting to add that practically all the gold mines in South Africa—the Robinson and a few others excepted—pay their dividends from their recoveries by cyanide; and this observation applies with still greater force to the gold mines of the Waiki (New Zealand) and Kalgoorlie (West Australia) districts. Indeed, the cyanide process seems to have taken a firm hold of the gold mines of the world with the notable exceptions of the Gympie and Mount Morgan districts, of Queensland. A 6-dwt. rock is now regarded as profitable, and sand with less than 1½ dwt. per ton as worth large installations. Contrast this with the 5 dwt. to 20 dwt. tailings of 1888.

The one district of Witwatersrand now produces more gold than the total output of the world in 1888, which itself was little more than one-quarter of the present figure—22,000,000 for 1888 and 82,000,000 for 1907.

The address then refers to the valuable results of the international exchange of ideas, together with the aid of the technical press, and concludes by suggesting standardization of terms, practice and mining accounts.

Metallurgical Research at the National Physical Laboratory During 1907.

Thermometry at High Temperatures.—For the Féry type of radiation pyrometer with mirror, provision was made for simultaneous testing of ten instruments and a standard on a "black-body" furnace, the temperature of which is measured by a thermocouple and a potentiometer. With this particular type of radiation pyrometer no window may be interposed at the mouth of the furnace on account of the great proportion of the radiant energy employed lying in the red and infra-red parts of the spectrum; and the size of the mirror—3 in.—necessitates an aperture of considerable diameter, and, consequently, a large furnace. The furnace used was of the ordinary type with platinum foil winding, and was capable of giving temperatures up to 1,400° C. To minimize the effect of convection currents

the mouth was inclined downward at an angle of about 30 deg. with the horizontal. It was found that the cooling effect of the current of air in the mouth of the furnace produced a very steep temperature gradient in the procelain tube, causing the fairly rapid destruction of both tube and foil.

A furnace was then built with the tube placed vertically and surrounded by a thick lagging of magnesia in a firebrick casing. This was found to take less power, and to give a very uniform temperature throughout and better insulation in the thermocouple circuit. The pyrometers were mounted vertically on a turntable, by the rotation of which they were brought successively under the furnace mouth. Experiments have also been made on a new type of "hot strip" as a secondary standard.

A description will shortly be published of an improved carbon-tube furnace designed to obviate the alterations in specific resistance and mechanical properties due to graphitization, as well as other defects, which has given very good results, and is adapted for uniform heating of fairly large objects to about 2,500° C. It has been employed for the study of the melting and boiling points of a number of metals and oxides. Some of these melt over a *range* rather than at at definite *point;* others, which are cheap and easily obtained, seem suitable for use as standard high-temperature melting points.

For very high temperature work in "cascade furnaces" (see our vol. III, p. 273), with solid electrolytic conductors, tubes of refractory oxides—both pure and mixed—have been made up to considerable diameters; and difficulties encountered in early attempts to squirt such tubes have been overcome. Substantial progress is anticipated during 1908 in the construction of larger cascade furnaces of the type used two years ago in the work on the melting point of platinum, and it is hoped that by the use of this type of furnace an attempt may be made, in conjunction with the photometric department, to realize the Violle standard of light as defined by the radiation from 1 sq. cm. of platinum at its solidifying point.

In connection with platinum thermometry, recalibration of the platinum-thermometer bridge, referred to in the report for 1907, shows that the changes in the coils have been very small, while a restandardization of all the British Association standard platinum-thermometers demonstrates that no certain changes have occurred in their constants.

The standard thermocouples, too, exhibit no noteworthy variation. Many high-range mercury thermometers have been tested during the past year, and a considerable general improvement in the quality of these is noted, but low-range mercury thermometers are less satisfactory. The properties of fused silica at high temperatures are being thoroughly investigated, and the test will include an examination of the effect of prolonged heating on its mechanical properties and a determination of its coefficient of expansion up to its softening point.

The Programme of Research Work at the National Physical Laboratory for 1908.

The Engineering Department proposes to undertake, among other work, the investigation of the resistance of materials to impact, in connection with which the adoption of standard tests is contemplated. The experiments begun in 1907 on the resistance of surfaces and solids in a current of air at high velocities will be continued with the view of designing and constructing full-sized apparatus for such work. Experiments on the resistance of materials to abrasion will be further conducted, with steel rails in particular, under conditions which will more nearly approximate to actual working conditions than was the case last year. The investigation of the elastic limits of materials under alternating stress will be carried on by testing specimens which have been subjected to many reversals of a stress less than the limiting stress, and by trying to vary the elastic limits by overstrain and recovery.

The Department of Metallurgy and Metallurgical Chemistry will proceed further with the investigation of the alloys of copper and aluminium with, firstly, manganese and later with nickel and zinc; and with these ternary systems a complete series of tensile, impact, alternating stress, hardness and corrosion tests will be made.

The Seawater Corrosion Tests on alloys at Portsmouth will be continued, and a series of similar tests will be begun at Malta.

It is hoped that the proposed work on *Cooling Curve Methods* may result in the setting up of a satisfactory form of autographic apparatus for obtaining recalescence curves of metals and alloys.

With the apparatus that has been set up for focussing by aid of monochromatic blue light, it is anticipated that the work on *Photo-micrography of Metals by Ultra-violet Light* will yield satisfactory results at very high magnifications.

The Eutectic Alloys Research will be carried on. The lead-tin series will be satisfactorily explored first, and a detailed study of the constitution of the silver-copper group will follow. At present the observed facts in the lead-tin series are not easily reconciled with the view that the constituents of an eutectic alloy are necessarily similar in constitution as well as in composition to the corresponding "free" constituents. This point will receive especial attention in studying other series. Differences between various members of the same series of alloys in respect of the amount of contraction they undergo during solidification will also be studied—in the first place with the lead-tin series. The location of the maximum or minimum of contraction on freezing will also be of interest. At present it is proposed to confine this work to alloys having comparatively low melting points.

Iron and Steel and General Metallurgical Analysis.—The accuracy of various methods of analysis is to be thoroughly examined and checked by comparative analyses of standard samples and by comparison with other methods, and new methods are to be tried.

Market Prices During April.

During April tin has undergone some sharp jerks, rising to £145 on the 3d, and dropping to £142 on the 7th. Thence a fairly steady rise to £144 per ton.

Lead has shown a steady downward tendency from £14 10 0 at the beginning of the month to £13 12 6 at the time of writing.

Copper, Standard, dropped fairly steadily from £59 to £58 without excessive alterations.

In the iron market, hematite pig (Scotch) is at 61/-, slightly down. For Cleveland pig there is little demand; a slow rise to 52/- took place. Clyde pig is quoted at 64/6.

Chemicals register the following prices:

	£	s.	d.
Ammonia sulphate, f.o.b. Liverpool, per ton	12	5	0
Copper sulphate, per ton	24	0	0
Caustic soda, 77 per cent. white, per ton	11	2	6
Bleaching powder, 35 per cent., per ton	4	10	0
Carbolic acid, 97/99 per cent., per gal		1	0
Creosote oil, good ordinary liquid, per gal			2¼
Shellac, Standard T. N., orange spots, per cwt	4	15	0
Antimony, Star Regulus, per ton	£33 to 35	0	0

International Congress of the Refrigerating Industries.

The first International Congress of the Refrigerating Industries will be held in Paris, France, from Sept. 17 to 23, 1908. A very elaborate program has been arranged and the Transactions will be printed in book form.

There are six different sections, devoted to low temperatures and their general effects; refrigerating appliances; the application of refrigeration to food; the application of refrigeration to other industries; the application of refrigeration in commerce and transport; legislation. We will print a fuller program in our next issue.

The officers of the American Committee are: Mr. Homer McDaniel, president; Mr. John E. Starr, vice-president; Mr. John S. Field, treasurer, and Mr. J. F. Nickerson, 315 Dearborn Street, Chicago, secretary.

RECENT METALLURGICAL PATENTS.

Iron and Steel.

Refining and Purifying.—An important saving of time and gain in yield in steel manufacture are claimed to be the advantages of the preparatory process of Henry D. Hibbard (885,248, April 21, 1908). The object is to utilize the calorific power of metalloids in crude iron in the reduction of iron from its oxide, so as to furnish a purified and refined iron to the open-hearth furnace or converter. The treatment of the crude iron may result in the following three effects: (1) refining, i. e., elimination of silicon and manganese; (2) purifying, i. e., elimination also of phosphorus and sulphur; (3) also partial decarbonization. The treatment is carried out in a vessel charged with a quantity of molten crude iron and oxide of iron. The crude iron must contain sufficient metalloids to give, by their oxidation, enough heat to reduce a sufficient amount of oxide or iron, to supply the necessary oxygen and maintain the charge in a molten condition during the treatment. By a special method of agitation of the charge which will be described below, the reaction between the metalloids of the crude iron and the oxide of iron will be started and will burn the metalloids which will generate sufficient heat to keep the mixture molten, as well as to reduce the chemical equivalent of iron from its oxide and to form the slag, and this without the addition of fuel or heat to the vessel beyond that added in the two ingredients. The quantity of ore or other oxide of iron added is proportioned to the amount of crude iron used and the amount of decarbonization desired in the product. Only enough oxide of iron may be added to the charge to burn the silicon and manganese, and in some cases the phosphorus, or more may be added to burn a part of the carbon. Enough carbon is kept in to lower the fusion point of the iron to the proper degree in order to keep the refined metal liquid at the temperature of the process. The apparatus in which the process is carried out is a vessel with two pockets, with a dividing partition between them. The charge introduced into the vessel is mixed by oscillating the vessel back and forth upon its axis so that the molten charge is poured over the dividing partition wholly or in a large part at each oscillation, the lighter oxide on the top going first and the heavier metal then passing through it. This repeated pouring of the heavier metal through the lighter oxide is an important feature of the process. The vessel is oscillated back and forth so as to rapidly pass the metal through the oxide of iron. Some thermochemical calculations are given to illustrate the principle.

Alloy Steels.—Hitherto the temperatures of the bath have ordinarily not been carried beyond 2500 or 3000° F. when melting metals to form steel. James Churchward (884,009, April 7) points out that such temperatures are not sufficiently high in the manufacture of alloy steels to "bring the alloying metals into a proper condition for entry and interchange." The evident reason is the very high melting point of most of the elements introduced into alloy steels. Each of the steel alloys takes a different period of time to enter and interchange and these periods vary from 30 seconds to 30 minutes dependent on how refractory the alloying metal is. By bringing the temperature of the metal bath to about 3100° F. or 3600° F. and holding it at this temperature for a period of from 15 to 60 minutes the metal becomes in a more receptive state to interchange and enter into union with the alloying metals than it does at a temperature below about 3100° F. The application of this method to the manufacture of nickel-chromium-manganese steel is described.

A special nickel-chromium-tungsten steel is patented by R. H. Illingsworth (882,112, March 17, 1908, assigned to Crucible Steel Company of America). Steel of approximately 0.60 per cent. carbon and containing substantially 2.50 per cent. nickel, 1.25 per cent. of chromium and 1 per cent. of tungsten shows, after hardening in oil in the well-known manner, a high elastic limit and high tensile strength combined with high elongation.

Puddling Furnace.—In our vol. IV, p. 353, we described in detail Mr. James P. Roe's mechanical oscillating puddling furnace. A recent patent granted to him (881,342, March 10, 1908) relates to the construction of the hearth. The bottom of the hearth is inclined downwardly from each end to a middle part on an obtuse angle. An arched bow-shaped roof is provided high at the center and ends and low at the intervening parts.

Nodulizing.—The treatment of pulverulent iron ores in a rotary gas furnace to ball them together for subsequent treatment in the blast furnace, is the subject of a patent of H. Dicke (886,683, May 5, 1908). It is pointed out that dusty or pulverulent ores should be fused either without any additions at all or at least with such small quantities of added matter, as will enable the fusion to take place only at a temperature of 1000° C., in order that the agglomerated ore shall withstand any temperature less than 1000° C. In order to effect this, it is necessary to work with a pointed flame, and, above all, the gas must be supplied under an excess of pressure. This excess of pressure of the gas, which may be effected by collecting the gas in a gas holder, is believed to be absolutely necessary for the regulating the shape and the oxidizing capacity of the flame.

Sintering.—E. B. Clark (887,379, May 12, 1908) proposes to make fine ores, flue dust, pyrites, residue, etc., available for use in the basic open-hearth process. The fines are treated in a long inclined rotary kiln, which they leave in a semi-plastic condition to the compressing rolls, which compress the agglomerated ore into the form of blocks or lumps of suitable size to be used instead of ore in the open-hearth process.

Aluminium.

Aluminium Alloy.—W. Grossmann (886,579, May 5, 1908, assigned to Fried. Krupp, A. G.) patents an aluminium alloy which has several valuable properties over the known aluminium alloys of small specific gravity, such as alloys of aluminium and zinc. The new alloy consists of about 87 per cent of aluminium, 8 per cent of copper and 5 per cent of tin. The content of copper in the alloy may vary between 7 and 8.5 per cent, and the content of tin may vary between 4.5 and 5.5 per cent. The alloy can be easily cast. The castings are completely homogeneous and have relatively high rigidity.

Gold.

Extraction of Metallic Values.—D. R. Robertson, of Denver, Col., (886,886, May 5, 1908), patents a process, the application of which to the extraction of gold and copper from ore is described as follows: A ton of crude ore, reduced to about 80 mesh, is mixed with 2 gal. of aqua regia and enough water is added to reduce the mass to the consistency of soft mud. This mass is agitated and steam is applied to it for a period of about two hours gradually bringing it to the boiling point. Enough cold water is then added to equal 30 per cent of the weight of the mass. The mixture is drained through a filter into a precipitating tank, containing about 20 lb. of old scrap iron or iron rust and maintained at a temperature from 65 to 70° F. The metallic values are precipitated on the iron and may be removed by scaling off. The process is said to be applicable to high- or low-grade ores. With softer ores which yield quickly to the treatment, the expense is comparatively less.

Cyanide Plant.—H. L. Templer, of Cleveland, Transvaal (886,892, May 5), patents the following method of handling the ore from the time it leaves the stamps or amalgamation plates until it is deposited in vats or otherwise prepared for treatment by cyaniding. The pulp coming from the battery or from the amalgamated plates is passed by a launder to a mechanical classifier (for instance, a Wilfley table set) to separate the battery pulp into three parts, the first consisting of substantially dry concentrates, the second a pulp of sands and water, and the third slimes mixed with the bulk of the crushing water. The slimes and water are passed off into a

chute and are carried away by a launder for disposal in any desired manner. The sands pulp is delivered from the classifier into a chute from which it falls onto a traveling web screen. The water associated with the sands and also any slimes therewith pass through the screen into a discharge launder thereunder and may conveniently be led thence into the slimes launder. The sands pass over the screen in a substantially dry state and drop onto a conveyer by which they are carried to the sands lixiviation vats. The concentrates being delivered dry by the separator, are taken directly, for instance, by a belt to separate lixiviation vats, but in cases where it is not feasible to deliver the concentrates dry, the water is first separated from them by a moving screen, as in the case of the sands. In many instances the concentrates, instead of being treated immediately with solvent, are required to be reground in tube mills, grinding pans or other similar apparatus. In such instances the concentrate lixiviation vats are dispensed with and the belt carries the concentrates—dry as before—to the tube mill; it being found to be advantageous to feed the mill with substantially dry material and to feed by separate means the exact quantity of water necessary for grinding, since the amount of water necessary to carry the material as pulp is largely in excess of that required for grinding. Several modifications of the arrangement are described.

Slimes Treatment.—C. E. D. Usher, of Johannesburg, Transvaal, (886,900, May 5, 1908), treats slimes by percolating the solvent solution or wash water upwards through the slimes which are maintained in a uniform and practically constant state of diffusion throughout the suspending liquid, the rate of flow and manner of distribution of the solvent or wash water being such as to maintain the slimes in suspension and yet allow the solvent or wash water to collect in a clear state above the slimes, whence it may be withdrawn as desired. The process is carried out in a cylindrical vat, the slimes and the solution being introduced through two concentrical hollow tubes, in the center of the vat. The lower end of the slime tube is open, while the lower end of the solution tube connects with several side arms with apertures through which the solution is sent upwards.

Copper.

Wet Process.—L. Jumau (883,962, April 7, 1908), leaches copper ores with an ammoniacal solution and then treats the solution with sulphurous acid, precipitating copper in form of cuproso-cupric sulphite. The precipitate is then heated under pressure in the presence of an aqueous solution, for instance, the solution from which the precipitate has been thrown down. The final operation of the last step, omitting certain intermediate reactions, may be stated as follows:

$$CuSO_3.Cu_2SO_3 + 2H_2O = 3Cu + 2H_2SO_4.$$

The copper precipitate thus obtained is absolutely pure and free from sulphite or oxide of copper. The above-described reaction is found to begin between the temperatures of 140° C. and 160° C., and to become nearly completed at 470° C. The process can, therefore, be conveniently carried out in any usual lead-lined digester of copper or iron.

Yellow Brass.—R. Stribeck (887,540, May 12, 1908) remarks that all species of latten (yellow brass), which are actually on the market and which are called susceptible of being rolled and cast into molds, affect more or less considerable brittleness when exposed to or worked at temperatures between 300 and 550° C., so that they cannot be used for numerous purposes. Such brittleness is caused by a certain percentage of lead or oxides, or both, which cannot be avoided in the usual methods of production of the alloys. The present inventor tries to avoid this "hot-brittleness" of yellow brass by the addition of a certain quantity of phosphorus, the percentage of the latter being provided in order to produce an alloy in which 0.03 to 0.10 parts of phosphorus are contained per 100 parts of total weight of the alloy ready for being worked or otherwise used. Latten toughened according to this method is said to be available for numerous applications in which it is exposed to high temperatures. As an example of such cases in which common latten-alloys are unsuitable may be cited pipings conducting superheated steam, etc.

Lead.

Treatment of Galena.—A. Francis (882,193, March 17, 1908) melts galena with a suitable flux and then introduces the molten matte into a furnace containing molten lead, so that the molten lead sulphide floats on top of the bath of molten lead. By blowing air through the bath the lead is oxidized and combines with the sulphide, thereby converting the sulphide into metallic lead. For every two parts of lead oxidized three parts of metallic lead are produced.

SYNOPSIS OF PERIODICAL LITERATURE.

Electrochemistry.

Electrolytic Alkali and Bleach Industry.—In the Lond. *Electrician*, April 24, J. B. C. Kershaw gives a review of this industry in 1907. He estimates the total number of works as 36, with a total power available of 67,000 hp, equivalent to an output of 134,000 tons of 70 per cent caustic soda and 280,000 tons of 35 per cent bleaching powder per year. The (British) Castner-Kellner Alkali Company have paid 12 per cent dividend during the last year, the success being attributed to the scrap of old plant, notably the substitution of a Mond gas plant and Koerting gas engine for an old steam plant at one of their works. Part of the chlorine produced is used by the company for making zinc chloride by the Swinburne-Ashcroft process. A new Italian plant has been started since The Société Elettrochimica del Coffro has completed a plant for producing caustic soda and chlorine by a modification of the Kellner cell and process. The caustic soda is sold in the form of a solution concentrated to 38 deg. Baume. The company uses common salt from Sicilian mines as raw material, and the plant has a working capacity of 20 tons a day.

Metallic Mirror for Search Lights.—Ever since the introduction of search lights for battleships, attempts have been made from time to time to substitute metallic mirrors in place of glass ones, which are unsatisfastory, due to the fact of their being so readily broken by concussion when firing the guns, and that the silvering at the back of the mirrors is very liable to blister and leave the surface of the glass. The difficulty of making true parabolic mirrors has been overcome by the Cowper-Coles electrolytic process which, as described in Lond. *Elec. Eng'ing*, April 9, briefly consists of depositing by chemical means on the convex side of a glass former or mould a thin silver film and then spinning the former in an electrolytic cell charged with copper anodes and a copper electrolyte, so as to deposit the copper on the silver surface, the process being continued until the silver film has received a sufficient thickness of copper to give the desired rigidity to the parabolic mirror. The glass mould and the electro-deposit are then removed from the depositing cell and placed in a vessel containing cold water, the temperature of which is gradually raised until the expansion of the copper is sufficient to cause the metallic mirror to leave the glass former. The silver-faced mirror thus produced has as highly polished a surface as the glass, and is finally subjected to an after-treatment to prevent the silver from tarnishing and then mounted in a metallic ring (which fits in the projector case) provided with knife edges, which firmly grip the edge of the mirror without distorting it. A large number of mirrors made by this process have been supplied to the British government, some of which were sent out to the South African War. Mr. Cowper-Coles is now introducing a new metallic miror which is only partially made by electro-deposition. The mirror has a surface composed of alternate bands or rings of gold and white reflecting surfaces which, it is claimed, give a more penetrating beam of light both at night and in foggy weather. Objects on which such a beam of light

is thrown stand out in greater relief than in a light thrown from a silver-white metal mirror, and the intensity of the light is so great that it is impossible to aim accurately at the projector. Another advantage claimed for the new mirrors is that they are not fractured by concussion, and even when penetrated by bullets the area of distortion is very small.

Electric Laboratory Furnace.—A new electric laboratory furnace is described by L. Clerc and A. Minet in a recent issue of *Comptes Rendus* and in the Lond. *Electrician* of April 24. One of the authors noticed that the length of an arc playing in a cavity at the center of a refractory mass, such as lime or magnesia, reached several centimeters for such electric constants as 40 amperes and 50 volts. When these experiments were repeated the two following facts were observed: (1) For a constant e.m.f. from 50 to 60 volts, the arc could be given any length on the condition that the transverse section of the cavity was varied in proportion to a certain power (greater than unity) of the arc length, and at the same time the current was varied in proportion to another power (less than unity) of this section. The values of these powers correspond to a practically constant arc temperature. (2) When the arc is burning properly a crucible of some refractory conducting substance, such as carbon, or non-conducting material, such as

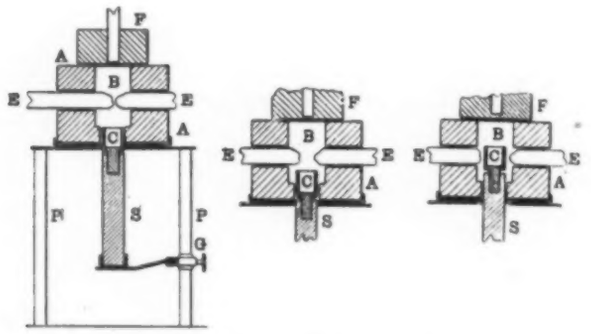


FIG. 1, 2, 3.—ELECTRIC FURNACE.

lime or magnesia, can be introduced into the arc without extinguishing or altering the electrical constants. An electric furnace designed on these lines is shown in Figs. 1, 2 and 3, these being three different positions of the crucible. The furnace consists of two principal parts (A and F) and is made of a refractory substance, such as lime or magnesia. The part A is bored out cylindrically along a vertical axis, two chambers being thus formed. One of these (B) is the furnace, whose dimensions are 3 cm in diameter and 6 cm high. The other, whose diameter is 2 cm is a continuation of the first, and through it the crucible (C), whose capacity is about 2 cubic cm, can be introduced. The crucible is held up by a support (S), made of a non-conducting substance, such as lime or magnesia, having an arm terminated by a slider (G), which is provided with a set screw, so that it can be moved along one of the supports (P) of the apparatus. The crucible, therefore, may be raised and occupy a position in the furnace (B) in accordance to the distance apart of the electrodes (EE), which are made of carbon. By employing 1 kw to 2 kw experiments can be made in this furnace at all temperatures, from a dark red, when the crucible and electrodes are in the position shown in Fig. 1, to the temperature of the arc (Fig. 3). The capacity of the crucible is sufficient in all cases to contain from 2 to 40 grams of material, according to its density. With currents from 30 to 40 amperes the arc can be maintained in spite of the consumption of the carbons. It is, however, possible to separate the electrodes to their extreme limit without the arc going out, and if the electrode, having first been taken out, is reintroduced quickly into the apparatus the arc is struck when the carbons are still apart. Current leakage due to the walls of the apparatus when at a temperature equal to that of melting magnesia need not be taken into account.

Metallurgy.

Phosphor-Copper.—A recent Faraday Society paper of Prof. A. K. Huntington and Dr. C. H. Desch deals with "the planimetric analysis of alloys and the structure of phosphor-copper." The authors discuss the conditions under which it is possible to estimate the relative proportions of the constituent metals of an alloy by means of a planimetric measurement of the areas of the solid phases exposed in a polished and etched micro-section. Details of the method are given, and its accuracy is shown by a series of measurements of analyzed alloys. The method has been most fully studied in the case of phosphor-copper, of which a number of photo-micrographs were shown. In the case of alloys containing less than the eutectic proportion of phosphorus, however, the area of the copper crystals is found to be considerably greater than that calculated from the composition determined by analysis. The origin of the discrepancies was traced to the segregation of the eutectic, the copper crystals which separate at first drawing to themselves a portion of the copper of the surrounding eutectic. The crystals are, therefore, surrounded by a belt of copper phosphide. By measuring the area of this belt and thence calculating the amount of segregated copper, a correction may be applied to the area of the crystals, and a very satisfactory agreement with the analytical results is thus obtained. In the discussion it was stated by Dr. Desch that the method could not be of quite general applicability, it being useless, for instance, in cases of homogeneous alloys. It was also necessary for the alloy to be in a state of physical equilibrium. Prof. Huntington added that the method would probably be usefully extended to the case of phosphor-tin alloys.

Interaction of Aluminium Powder and Carbon.—This subject is discussed in a recent Faraday Society paper by Frank E. Weston and H. Russell Ellis. Very little work has been done on the combination of Al and C at temperatures lower than that of the electric furnace. F. Fichter (*Zeitsch. Anorg. Chem.*, 1907, 54), using a mixture of soot and aluminium, produced an impure aluminium nitride; Matignon (*C. R.*, cxlv., No. 17, 1907), using a mixture of lampblack and aluminium, obtained a product, on heating in a Perrot furnace, which yielded a gas with water consisting of 96.36 per cent CH_4 and 3.36 per cent H. The authors have shown that the Al powder and carbon can be made to react at temperatures much below that of the electric furnace. Mixtures of Al powder and carbon, wood charcoal, sugar carbon and graphite have been prepared, in which reaction takes place in starting with a fuse of Mg powder and BaO_2 as in Goldschmidt's reaction; other mixtures have been made which only react when heated at temperatures varying from 400° C. to 1000° C. In all cases the products of reaction were found to be aluminium carbide (9.12 per cent to 65.91 per cent), aluminium nitride (3.67 per cent to 42.16 per cent), alumina (11.07 per cent to 55.4 per cent), aluminium and carbon. The carbide produced is most probably that described by Moissan as Al_4C_3, since the gas obtained on treating the product of reaction with either water or hydrochloric acid was found to consist of CH_4 and H, the latter coming from (1) the action of HCl in unaltered Al, (2) action of NH_3 on Al, the NH_3 being formed by the action of water on the aluminium nitride. The authors are of opinion that the chief cause of the reaction is to be found in the initial oxidation of the carbon, by atmospheric (and occluded) oxygen, to CO and CO_2, the heat of this reaction causing the oxidation of some of the Al to Al_2O_3, and the heat of this reaction causing the combination of the Al with carbon and atmospheric (and occluded) N. This view is supported by the fact that very little action took place in a mixture of Al and wood charcoal when heated to bright redness, *in vacuo*, in a steel tube, while the same mixture reacted energetically when heated in an open basin to just visible redness. In the discussion which followed, Dr. F. M. Perkin did not agree with the authors' view as to the cause of the reaction. There was no evidence that at 1100° CO could be reduced. Possibly the reaction was started by superficial oxidation of the

aluminium. C. Weiss referred to the aluminium carbides found at the bottom of the furnaces in which aluminium is made. As a rule, these carbides were entirely enclosed in a coating of alumina. H. R. Ellis gave some further particulars regarding the nitride produced, probably by the action of nitrogen at a high temperature on the aluminium carbide. As crude aluminium carbide can be made by heating clay and carbon in the electric furnace, this method might be as economical a one for the fixation of atmospheric nitrogen as the combination of calcium carbide and nitrogen to form cyanamide. Prof. A. K. Huntington suggested that perhaps the author's reaction was a triple one, brought about by the presence of a gas (CO_2 or CO) between two solids which would not react alone. The gas, unlike the carbon, might be able to permeate the film of oxide surrounding the aluminium, getting at the actual metal, and so start the reaction.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Low Carbon Ferro-Alloys.—E. F. Price, 886,858, May 5, 1908. Application filed Sept. 24, 1907. Assigned to Electro Metallurgical Company.

In the first step of the process a high-carbon ferro-alloy is produced by smelting a mixture of the ore of the alloying metal, an excess of carbon and a source of iron in an ordinary electric furnace with a carbon lining and with carbon electrodes. In the second step the carbon is removed from the ferro-alloy in an electric induction furnace at a high temperature by passing air through the molten alloy. The oxygen of the air burns the carbon while only an unappreciable loss of the alloyed metal by oxidation is encountered. At the high temperature employed the affinity of oxygen for carbon is greater than for the alloyed metal. (This is the reverse of the conditions in the Bessemer process.)

Cupro-Titanium.—A. J. Rossi, 12,764, March 17, 1908. Application filed May 29, 1902. Assigned to Titanium Alloy Manufacturing Company.

Aluminium ingots are charged into a bath of molten copper in an electric furnace and titanic acid is added in moderately coarse grains. The aluminium reduces the titanic acid and by the heat of this reaction, together with the electric heat, a molten copper-titanium alloy is produced with a slag of aluminium oxide. The first three claims refer to the process of manufacture, while the last two claims refer to the product. The fourth claim reads as follows: "As a new article of manufacture a compound or alloy containing an important quantity of copper, say, not less than 10 per cent of the mass, and titanium in industrially important proportions; that is to say, not less than 5 per cent of the mass."

Calcium-Carbide Furnace.—E. F. Price, 886,856, May 5, 1908. Application filed Nov. 14, 1905.

The furnace has an open bottom beneath which is a movable receptacle which receives the molten product and is shifted to withdraw its contents from the product remaining in the furnace. A series of separate receptacles is employed, each serving in turn as the hearth or crucible of the furnace.

Manufacture of Refractory Articles of Magnesia, Etc.—C. F. Burgess, 884,463, April 14, 1908. Application filed May 31, 1906.

Fig. 1 shows the apparatus used for making magnesia crucibles. The vessels 1 of carbon contain a charge 2 of pure magnesia, within which are centrally disposed conductors 3 of carbon or graphite of such a shape as to conform to the interior of the vessel to be produced. These graphite conductors act as resistors. As shown in the illustration, they are inserted between fixed graphite blocks 6. The surfaces of the magnesia article next to the resistor 3 become sufficiently smooth and regular, but difficulty was found in producing also smooth outer surfaces of the article. This difficulty is overcome by inserting a layer 7 of paper. By this simple means the portions of magnesia outside of 7 are readily separable at the surface 7 so that the contour of the magnesia crucible conforms to the original position of the layer 7.

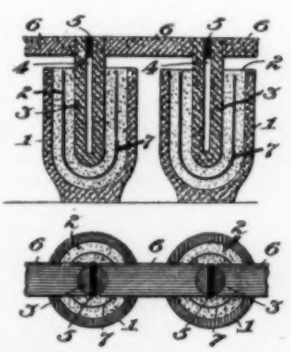


FIG. 1.—MAGNESIA FUSING.

Graphite-Amorphous Carbon Electrode.—E. F. Price and F. J. Tone, 887,123, May 12, 1908. Application filed Jan. 8, 1906

Artificial graphite produced in the electric furnace is ground and mixed with a suitable hydrocarbon capable of being converted into a permanent binder. The mixture is then molded and baked at a temperature sufficient to decompose the hydrocarbon and drive off the volatile constituents leaving the residual carbon, which serves as a binder for the graphite. In order to produce electrodes with a lower heat conductivity than graphite and a higher electric conductivity than amorphous carbon, a portion of the graphite in the mixture is replaced by ordinary amorphous carbon. According to the proportions used the thermal and electric conductivity may be adjusted. The resulting electrodes are dense, strong and can be easily machined.

Fused Peroxides.—G. F. Brindley, 884,563, April 14, 1908. Application filed March 13, 1906. Assigned to Roessler & Hasslacher Chemical Company.

The object is to fuse materials of a corrosive nature without decomposing the same and destroying the containing vessels. The process is especially adapted for fusing alkali peroxides. The material is fused by means of an alternating current passed through it between electrodes in such a way that the current density is low in the material adjacent to the electrodes and high within the material to be fused, while a layer of non-fused material is formed and maintained on the inner walls of the containing vessel between the walls and the electrodes.

Artificial Mica.—F. J. Machalske, 885,934, April 28, 1908. Application filed March 21, 1907.

The materials of which mica consists (except the caustic alkalies) are melted in an electric furnace of the induction type in the proper proportions and to the molten mass the caustic alkalies are then added. The mass is then discharged and cooled slowly in an atmosphere charged with moisture. The water entering into the constitution of the artificial mica product is derived from the alkali metal hydrate and from the moisture of the atmosphere.

Electrolytic Furnaces.

Lead from Sulphide Ores.—E. F. Kern, 885,761, April 28, 1908. Application filed Sept. 1, 1906.

If lead sulphide ore, which is a conductor of electricity, is made the anode in a suitable fused electrolyte, which has a melting point below that of the ore, the lead and associate metals of the ore may be deposited at, or in, the cathode, while the sulphur with which the metals are combined, is liberated from the bath, provided the temperature be above the boiling point of sulphur, which is 445° C. Frequently the natural galena is too fine; it is then melted with a suitable flux and the fused matte is cast into suitable blocks or cylinders to be used as anodes. As electrolyte a bath containing lead chloride is preferred. It has considerable dissolving power for lead sulphide, so that the bath is nearly or quite saturated with lead sulphide, giving an electrolyte which is fluid at 500° C. Other salts may be mixed with the lead chloride. The electrolysis is similar with different suitable electrolytes, the main difference resulting from the different temperatures which depend on the melting point

of the bath. It is necessary that the melting point of the bath be below that of the sulphide ore so that the anodes remain solid. A bath liquid at about 500° C. is advantageous. The ampere-hour efficiency varies from 88 per cent to 94 per cent, the e.m.f. usually being about 2.5 volts with an anode current density of about 500 amperes per square foot. With a current density of about 1200 amperes per square foot, the e.m.f. varies from 4.5 to 6.0 volts. In either case, the distance from anode to cathode was from 1½ to 3 in. The lead which is reduced at the cathode is malleable, and free from sulphur, at least for all practical purposes, and the sulphur liberated at the anode is free from chlorine and sulphur chlorides. The zinc occurring in the lead ore is also recovered since it accumulates in the electrolyte.

Metallic Calcium.—E. F. Price and W. S. Horry, 886,857, May 5, 1908. Application filed Dec. 29, 1906.

A molten bath of calcium chloride or fluoride, preferably with additions of the corresponding salts of strontium and ammonium to lower the melting point, is electrolyzed with a composite anode of calcium carbide and a binder, any suitable cathode, for example, one of iron, being employed to receive the electro-deposited calcium. The anode gradually dissolves, the contained calcium recombining with the halogen ion to replenish the bath, while the carbon may float to the surface and be burned by the atmospheric oxygen. It is preferred, however, to dissolve calcium oxide in the electrolyte, in which case the oxygen ion is liberated at and combines with the carbon of the anode, correspondingly decreasing the consumption of electric energy, while the calcium ion of the oxide is deposited at the cathode simultaneously with that from the haloid salt.

Electrolytic Processes.

Nickel from Silicious Ores.—A. Chalas, 887,735, May 12, 1908. Application filed Sept. 6, 1907.

The object is to recover nickel from nickel-iron silicate ores, free from copper, such as are found in New Caledonia. In the first stage of the process the ore is reduced at a high temperature in an electric furnace to produce ferro-nickel, which is cast into convenient shape for anodes. These anodes are used in an aqueous solution of nickel-ammonium sulphate with nickel sheet cathodes. Pure nickel is deposited on the cathode, while nickel and iron are dissolved on the anode as double ammonium sulphate. During electrolysis, this solution is continuously circulated from the cell through a filter containing a body of precipitated nickelic hydroxide, which reacts upon the dissolved ferrous salt with production of nickel sulphate and precipitation of ferric hydroxide. The solution thus freed from iron and containing an additional amount of nickel equivalent to the removed iron, is continuously returned to the cell.

The nickelic hydroxide used for the precipitation is electrolytically produced from ferro-nickel anodes in an auxiliary cell with an aqueous solution of sodium chloride and sheet cathodes of nickel. As electrolysis proceeds, nickel and iron are dissolved from the anodes as chlorides, while a sodium hydroxide solution is produced at the cathode. These two solutions, when mixed, react with the production of nickelous and ferrous hydroxides, which preciptate, and sodium chloride, which dissolves and regenerates the electrolyte. The brine, carrying the precipitates in suspension, is circulated through a filter-press, which retains the hydroxides, the clear solution returning to the cell. When the filter-press has been filled with the pricipitated hydroxides, their peroxidation is effected by circulating through the mass an aqueous solution of an alkali-metal hypochlorite, produced, for example, by the electrolysis of a cold dilute solution of sodium chloride. The nickelous and ferrous hydroxides are thus readily peroxidized and the hypochlorite is reconverted into sodium chloride, which is re-electrolyzed.

Diaphragm.—H. Hirtz, 885,998, April 28, 1908. Application filed Oct. 3, 1905.

A textile diaphragm of asbestos cloth is dipped into a solution of alkali ferrocyanide or ferricyanide and then into a solution of copper sulphate. In this way an additional diaphragm is precipitated within the asbestos cloth. When the diaphragm is to be used for an electrolytic cell wherein a solution of a metallic salt that forms an insoluble double cyanide is to be electrolyzed, it is preferable to use a solution of this salt as one of those with which the cloth is to be impregnated and a simple manner of doing this is to saturate the cloth first with a concentrated solution of alkali ferrocyanid or ferricyanide and then either before or after it has dried to place it in position in the solution in the electrolytic cell, whereupon the desired deposition occurs while the cloth is in place.

Nickel and Copper from Matte.—J. M. Neil, 882,075, March 17, 1908. Application filed June 3, 1907.

Copper-nickel matte is roasted in a revolving or reverberatory furnace in the presence of carbon and air in order to expel any sulphur and arsenic. The temperature is then raised in order to melt the metals. Part of the molten alloy is cast into slabs, used afterward as anodes, and the remainder is run into water and thereby disintegrated; it is then treated with sulphuric acid in a dissolving tower, to produce a concentrated sulphate solution. This is used as electrolyte between the slabs, mentioned above, as anodes and thin copper sheets as cathodes. Copper is deposited on the cathodes and an equivalent amount of copper and nickel is dissolved from the anodes. Electrolysis is continued until the electrolyte contains nickel sulphate and a small percentage of copper sulphate. This solution is treated with a sulphide, either in form of sulphuretted hydrogen or in form of a soluble sulphide, until the copper, iron, zinc, etc., are precipitated as sulphides. The nickel sulphate solution is filtered and treated with a solution of calcium chloride or barium chloride, etc., resulting in the formation of nickel chloride and the precipitation of calcium (or barium) sulphate. The nickel chloride solution is then subjected to electrolysis, an insoluble anode and a nickel cathode being employed, resulting in the deposit of the nickel on the cathode. The calcium sulphate is mixed with carbon and roasted to convert it into sulphide which is treated with chlorine and converted into chloride. The sulphur is recovered and converted into sulphuric acid which is used over again.

Copper from Ores.—L. Jumau, 883,961, April 7, 1908. Application filed Jan. 19, 1907.

Copper sulphide ore is roasted to produce copper oxide which is lixiviated at a raised temperature by an ammoniacal solution, such as a sulphate or a sulphite of ammonia or a mixture of the two. Seventy grams of copper are readily dissolved per liter of solution. The free ammonia is driven off (to be employed in further lixiviation) and the solution is then subjected at a raised temperature to the action of sulphur dioxide (obtained from the roasting of the sulphide ores). The reaction is $3Cu(HO)_2 + 3SO_2 = CuSO_3$. $Cu_2SO_3 + H_2SO_4 + 2H_2O$. The sulphur dioxide is driven off and the sulphuric acid is used later on for lixiviation, together with the ammonia removed as before, while an extra supply of ammonia can be obtained by treating with lime the ammonium sulphate with which the lixiviating solution becomes enriched. The $CuSO_3$ Cu_2SO_3 is dissolved in an ammoniacal solution and this is electrolyzed while simultaneously carbonic acid gas is passed through the solution so as to convert the ammonia into carbonate. The copper is readily deposited from such a solution, while the passage of the carbonic acid gas also acts mechanically to promote circulation.

Electric Discharges Through Air.

Fixation of Atmospheric Nitrogen.—A. Grau and F. Russ, 884,919 and 884,920, April 14, 1908. Application filed Oct. 8, 1907.

The inner zone of an electric arc is at the highest temperature and within it the proportion of nitric oxide formed from atmospheric air is a maximum. In order to collect the nitric oxide,

it is important to withdraw the gas mixture quickly from the inner zone of the arc. While passing from the inner zone through the outer zones of the arc the nitric oxide would become again dissociated and some of the work done within the inner zone would be undone. To prevent this the inventors withdraw the gas mixture from the inner central zone of the flame by means of a tube of small diameter so that the gas mixture does not come into contact with the outer zones of the arc. The tube is of small diameter and projects into the inner zone and is protected by means of a water or air jacket which also serves to rapidly cool the gases which are withdrawn. Patent 884,919 relates to the process, 884,920 to the apparatus.

Fixation of Atmospheric Nitrogen.—D. Helbig, 887,326 and 887,476, May 12, 1908. Applications filed Jan. 23, 1905, and Jan. 5, 1906, respectively.

Atmospheric air is subjected to the action of an electric arc within a confined chamber lined with such metallic oxides (for instance, calcium and magnesium oxides) which when heated are capable of ionizing the gases in their vicinity so as to increase their electric conductivity. The electrodes are covered with the same oxide materials, the points of the electrodes extending of course beyond these materials. In this way it is possible to use a low-tension arc, say, at 300 to 600 volts, to have a very constant arc, which is not disturbed even by a very rapid gas current. The heat of the gas mixture formed is used to preheat atmospheric air introduced into the apparatus. 887,326 refers to the process and 887,476 to the apparatus.

Ozonizer.—A. Schneller, 886,874, May 5, 1908. Application filed April 25, 1904.

In the formation of ozone by the silent electric discharge with the aid of solid dielectrics of glass, etc., it is important to prevent overheating of the dielectrics. For this purpose the latter is cooled artificially by means of oil, benzol, carbon bisulphide, etc., which acts not only as cooling agent but also forms an additional dielectric layer.

Batteries.

Gas Cell for Utilizing the Energy of Oxidation of Carbon.—E. W. Jungner, 885,054, April 21, 1908. Application filed May 15, 1907; and 884,664, April 14, 1908. Application filed May 14, 1907.

The object is to convert "the caloric energy $SO_2 + O + H_2O = H_2SO_4$ into electrical energy for the purpose of enabling the reformation of sulphurous acid by means of the subsequent reduction of the sulphuric acid by means of carbon or other suitable reducing substance according to the following reaction: $H_2SO_4 + C = CO_2 + 2SO_2 + 2H_2O$. (The principal object of this becomes clear if we consider the operation as a cyclic process, each cycle consisting of two steps indicated by the above reactions. By multiplying the first equation by 2 and adding to it the second equation we get as the result of one cycle the equation $C + 2\,O = CO_2$, that is the complete combustion of carbon in oxygen.) The first step of the process is carried out in the apparatus shown in Fig. 2. A vessel B of earthenware is divided into two compartments by means of the porous plate P. D and A are plates of graphite. Around D are packed small pieces G of porous graphite, moistened with a solution of nitrosyl—sulphuric acid in sulphuric acid of high concentration. On each side of A are also packed smaller pieces *k* of porous coke or gas coal. They are chosen of the smallest possible size in order to get a very large surface, but enough space is left between them to permit the acid produced at the surface to flow down to the bottom of the cell by gravity. The porous division wall is saturated with sulphuric acid. Through the cover L, which closes the vessel as well as separates the two compartments gas-tight, pass the conductors A and D as well as the inlet and outlet-pipes R and *r*. If a current of air be conducted through the pipes R and a current of moistened sulphurous acid through the pipes *r* and if the poles of the battery be connected by means of a suitable resistance, a constant electric current is obtained, passing outside the battery from D to A. The reactions going on in the cell are discussed and it is concluded that the final result is a union of sulphurous acid, oxygen and water, forming sulphuric acid, while the other reacting substances remain unchanged. The sulphuric acid is formed at the pieces of coke around A and runs to the bottom of the vessel from where it is gradually drawn off through the valve *k*. The second step of the process —the production of sulphurous acid from sulphuric acid—is simply carried out by heating with coal, coke or the like. Some complications of the process are briefly referred to. The e.m.f. of the cell depends considerably on the concentration of the sulphuric acid and varies from 0.5 volt at medium concentration to 0.3 volt or less at higher concentration. The inventor prefers an acid of about 80 per cent H_2SO_4. Patent 884,664 refers to the depolarizer used, the first claim relating to "a depolarizer for galvanic elements comprising nitrosyl-sulphuric acid dissolved in concentrated sulphuric acid."

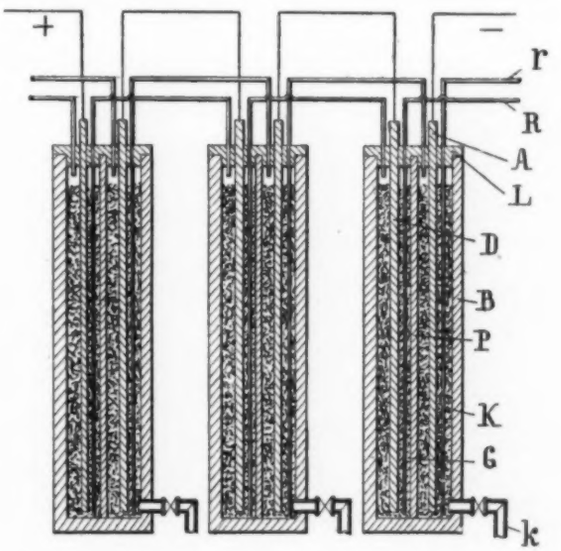


FIG. 2.—GAS CELL FOR UTILIZING THE OXIDATION HEAT OF CARBON.

Nickel Iron Battery.—E. W. Jungner, 884,930, April 14, 1908. Application filed Sept. 20, 1904.

To increase the conductivity of the active material it is mixed with graphite particles which are coated with a thin layer of nickel by electroplating.

Active Mass of Iron.—Hugh Rodman, 884,763, April 14, 1908. Application filed May 17, 1902. Assigned to Electric Storage Battery Company.

Fe_2O_3 is inert as cathode in an ordinary alkaline electrolyte, but is readily reduced to metallic iron in an alkaline solution containing a soluble sulphide, for instance a (10 per cent) solution of caustic potash, to which has been added potassium sulphide K_2S (5 per cent).

Storage Battery.—G. A. Carpenter, 884,264, April 7, 1908. Application filed Feb. 1, 1906.

The first claim refers to "the combination of a plurality of negative plates arranged in pairs, the individual plates of each pair being insulated from each other, connections for joining together one plate of each pair, separate connections for joining together the other plate of each pair, a plurality of positive plates sandwiched intermediate of said negative plates, one positive plate having a surface substantially equal to that of one pair of said negative plates, and connections for joining together said positive plates."

Storage Battery.—M. Margulis, 884,028, April 7, 1908. Application filed June 7, 1907.

The first claim refers to "an accumulator-plate consisting of a head-piece, a plurality of alternately straight and wavy lead strips suspended from the head-piece and provided with holes, a plurality of pressure strips suspended from the head-piece, and adapted to yieldingly compress the straight and wavy lead strips in the horizontal direction, and a plurality of horizontal cross rods passing through the holes of the straight and wavy lead strips and adapted to connect together the pressure strips."

Storage Battery.—W. A. F. Alt, 885,662, April 21, 1908. Application filed April 1, 1907.

The first claim reads as follows: "In a secondary battery, a plate of one sign, and a plurality of plates of the opposite sign, the aggregate area of said plurality of plates being substantially equal to the area of the single plate, means insulating the plates one from another, contact means carried by the plurality of plates adapted to engage like means, and means for separating the contact means."

Primary Battery.—C. B. Schoenmehl, 886,649 and 896,650, May 5, 1908. Applications filed May 29, 1905; 886,651, May 5, 1908. Application filed June 2, 1905; 886,652, May 5, 1908. Application filed March 29, 1906.

886,649 and 886,650 refer to a battery cover and element support. The first claim of 649 relates to "a battery bridge, and a supporting member, said bridge having a depending conical supporting-member protecting-lug extending below the solution surface." The claim of 650 reads as follows: "The combination with an electrode, of an electrode-supporting device, comprising a depending longitudinally extended protecting-sleeve having a shouldered and threaded upper portion, a member having a threaded recess extending partially therethrough, and a perforation continuing therefrom and adapted to register with the opening through said sleeve." In 651 the preparation of the copper oxide used in the cell is described. The mass of black copper oxide is first metalized (by reduction of electrolysis) and then reodixized (by heat or electrolysis) until the compressed oxide electrode becomes sufficiently and uniformly porous. By brushing or rubbing, a coating of pure copper powder is then applied to the porous mass. 652 related to the mechanical construction of the copper-oxide electrode. The first claim reads as follows: "A negative element for batteries comprising a thin pressed cylinder of metal oxide, and a perforated and pocketed sheet of metal extending therein and having its edges turned over to engage the cylinder and to support the same."

Primary Battery.—C. B. Schoenmehl, 888,407, May 19, 1908. Application filed July 21, 1906.

Mechanical details of a compact and durable zinc-copper oxide battery, for automobiles, yachts, etc. The zinc oxide cylinder is supported from the cover and enwrapped in a perforated insulating separator, surrounded by the zinc.

Primary Battery.—W. H. McDougall and S. R. V. Robinson, 880,689, March 3, 1908. Application filed March 9, 1907.

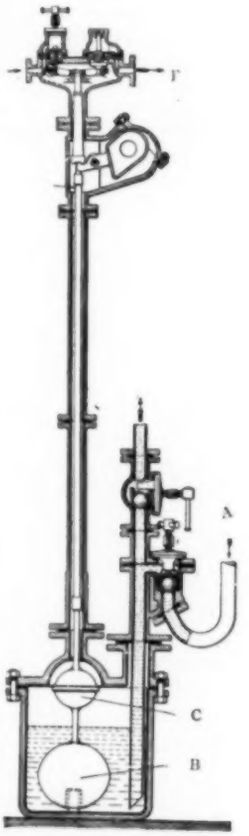
Details of construction of a primary battery in which the various parts are directly supported from the bottom of the cell, leading the circuit wire connections through the bottom. The parts are firmly held by cement or pitch, which also seals the openings and protects the connections. The elements are entirely submerged beneath the surface of the electrolyte.

Pocket Battery.—C. M. Wheeler and H. Wilhelm, 880,703, March 3, 1908. Application filed July 11, 1907.

The first claim refers to "a pocket battery comprising a plurality of cells, and a readily removable wrapper of flexible material, comprising a central portion having a pair of side extensions folded around said cells to inclose them, and also having a top and bottom extension folded over the ends of said cells."

Automatic Montejus.

The automatic montejus, built by the Schutte & Koerting Company, as shown in the adjoining illustration, is largely used where acids or other liquors are to be raised. Its success is due to absolute reliability under even the most trying working conditions. Owing to simple construction, it cannot get out of order, and requires no attendance whatever for many years. The mechanism is entirely enclosed, stuffing boxes and other parts subject to wear and tear being dispensed with.



AUTOMATIC MONTEJUS.

When the supply of liquid ceases, the montejus simply stops working, and starts of its own accord as soon as the feeding tank commences to fill. In the same way the montejus stops should the supply of compressed air or steam fail and restarts directly when the required pressure is available.

The pressure of the compressed air or steam applied can vary 30 to 70 lb. per square inch without interfering with the regular working of the apparatus. If required, the montejus can be constructed in such a manner as to allow the pressure of the compressed air to vary within wider limits.

The montejus performs from 30 to 60 operations per hour according to the varying circumstances. As the quantity of liquid discharged at each operation is always the same, the daily or weekly output can be controlled by means of a counting apparatus, registering the number of pulsations.

To summarize the advantages of the automatic montejus over the ordinary acid egg, we mention the following:

An ordinary acid egg which is emptied twice daily requires for this output a capacity of about 500 gal. The automatic montejus of 20-gal. capacity suffices for this purpose.

The acid egg must be placed in an easily accessible position and takes up considerable floor space. The automatic montejus can be placed in any out-of-the-way position, taking up very little room.

The acid egg must be attended to every 30 minutes. The automatic montejus requires no attention for years, as proved by experience.

The acid egg must be regulated by hand. Cocks and valves frequently stick or leak. In the automatic montejus all air and liquor valves are simple check valves, and are enclosed like the other mechanism. Stuffing boxes are entirely avoided.

A New Cyanide Plant.

The mill of the Montana-Tonopah Mining Co. is quite interesting in several of its technical features, as will be seen from the following description. The capacity of the mill is rated at 200 tons per day and the crushing plant is capable of handling double this quantity in a single shift if necessary.

The plant was designed by the Allis-Chalmers Company under the direction of Mr. F. L. Bosqui, consulting engineer for the Montana-Tonopah Mining Co. A remarkable feature of this plant is the short time consumed in building it and placing

it in successful operation. As soon as available for operating the entire mill after its erection it was placed in continuous operation and handled the rated tonnage practically from the start. The details had been worked out so completely in every point that the entire plant was a success commercially, metallurgically and mechanically from the start.

The ore from the mine is dumped into a steel ore bin at the head of the shaft and is drawn therefrom through an ore-bin gate of the counterbalanced type into a No. 5 Gates style "K" breaker. This crusher is set to crush all to pass a 2-inch ring. The product is delivered to a No. 5 "B" Gates continuous bucket elevator which elevates and discharges it into a Gates 40-inch x 12-inch iron-frame revolving screen without internal spiders and having 1-inch perforations. The product passing through the holes is delivered directly to the conveyor for transportation to the mill. The oversize which does not pass the holes is delivered by gravity to the two No. 3 style "D" Gates crushers. These crushers are of the special short-head type for fine crushing and are set to make a product which will pass a ¾-inch ring. The product of these crushers is also delivered to the conveyor above mentioned.

The ore now being all reduced to about ¾-inch size is conveyed by a traveling-belt conveyor, having a belt 14 inches wide, to the mill building. This conveyor is about 194 feet long and travels up an incline of about 40 feet in this distance. At the entrance to the mill building this conveyor discharges the ore on to another conveyor of the same size and type, but operating in a horizontal plane at an angle of 30° from the line of the other and it is about 91 feet long. This conveyor is provided with an automatic tripper or distributor which travels along the length of the ore bins in back of the batteries, delivering the ore automatically into the bins the entire length.

At the point where the ore is discharged from the first conveyor on to the second there is installed a Cole automatic sampling device to take a sample of the crushed ore. This is a very ingenious sampler and about the best devised sampler that is made for ore discharged from a belt conveyor. Mr. D. Cole, assistant manager of the Cananea Cons. Copper Co., made the first design and installation of this sampler at their mills, and it has proved a very great success. The arrangement is such that a cutter or sample scoop is made to pass through the ore stream and take a sample across the full width of the belt during its passage. The frequency of the sampler can be arranged for in the driving mechanism.

The crushed ore is drawn from the bins back of the batteries through ore-bin gates into the automatic feeders, which are of the suspended or hanging type which can be moved back from the mortars when necessary and thus give a large working space for making the usual repairs. There are eight bin gates and feeders, one for each battery.

There are forty stamps, weighing about 1050 lbs. each. They are arranged in eight batteries of five stamps each in a mortar and each battery driven by a belt and tightener from the countershaft. The batteries are made right and left-hand set in three post frames. The mortars are of the narrow rapid-crushing, quick-discharge type, and the principal battery parts are steel to insure maximum wearing life. The ore is crushed through 12-mesh screens on the mortars.

The pulp from each five-stamp battery is delivered to a 24-inch cone classifier or sizer which makes two products. The spigot, or coarse product of each, is delivered to a Wilfley concentrating table, of which there are eight in all, and the overflow from each cone is delivered to the two Dorr classifiers. The tailings from the Wilfly tables are also delivered to the Dorr classifiers by belt and bucket elevators, which are made necessary on account of the contour. In the Dorr classifiers a separation of the sand and slime is made mechanically.

It is aimed to crush all the pulp to one hundred mesh and finer in the tube mills and these classifiers separate that part of the pulp which is already crushed to this size and it is delivered to the thickening cones for concentration on vanners, as later mentioned.

The coarse sand product from the Dorr classifiers is delivered into two 5-feet x 22-feet Gates trunnion type wet-grinding spur-gear-driven tube mills. These mills are provided with silex flint brick linings 4 inches thick and the initial charge of pebbles for each mill is 10 tons. The sands are all ground to 150 mesh or finer in these mills and each mill discharges its product into a classifying cone 4 ft. diameter. These cones are for the purpose of separating any sands from the product which might have passed through the mill without being reground fine enough and these sands are elevated back to the Dorr classifiers to be again fed to the tube mills.

The finished product is delivered to spiral sand pumps by which it is elevated to two large settling or pulp thickening cones, where the excess of water is removed and sent to the cyanide plant. The thickened pulp from the bottom discharge is delivered to 16 Standard Frue Vainning machines or concentrators having endless rubber belts 6 ft. wide. These concentrators remove and collect any fine sulphides after regrinding, in addition to that saved by the Wilfley tables. This concentrate product is collected and dried, after which it is shipped to the smelters.

The tailings from the vanners and the overflow from the settling cones are delivered to any one of three de-watering tanks in the cyanide plant. These tanks are provided with filters through which the water is drawn off and flows to a final settling box to collect any slimes carried in suspension, after which it is delivered to a water sump tank to be pumped back for reuse in the mill.

The thickened and de-watered pulp from the settling tanks is drawn off from the bottom discharge through a pipe line connected to the suction of a centrifugal pump. This pipe line is arranged so that the contents of any tank can be drawn off and a cyanide solution pipe is connected up with same to introduce solution if desired. The pulp is delivered by the pump into the agitator tanks. There are six agitators of the Hendryx type for treatment of the pulp, this number being required on account of the predominating value being silver and requiring about 24 hours to bring same into solution.

After the required period of agitation the pulp is drawn from these tanks by a centrifugal pump and delivered into the pulp storage tank. This tank is provided with a stirring gear which keeps the pulp in gentle agitation to prevent same settling. From this tank the charges are drawn into the filter tanks as required.

The filter system used for removing the solution from the pulp is the Butters' vacuum system, consisting of two filter boxes, each containing 72 filter leaves. A charge of pulp is delivered to the filter box and after removing the solution by a vacuum applied to the filter leaves and following with the necessary washes, the pulp is discharged through the bottom from the filter leaves and is sluiced out to waste. The solution is collected in a small storage tank and is pumped through a clarifying filter press into any one of three precipitating tanks.

Precipitation is effected by means of zinc dust introduced in the form of an emulsion and with agitation by compressed air until the cycle is completed. The contents of the precipitating tanks is pumped up to the refining plant and the precipitate is collected by passing the material through filter presses where the precipitate is collected on the filters in cakes and the solution is delivered to the storage tanks for restandardizing and used again. The cakes collected are dried and shipped to the refineries for reduction to bullion.

The mill is driven throughout by electric induction motors of the Allis-Chalmers Co. and these motors are distributed so as to give unit drives to the various departments. The current used is bought commercially and is 60 cycle, 3 phase, 440 volts, transformed down from 6600 volts and distributed from the

main switchboard to the various motors located at the different points in the separate buildings.

The plant is arranged in separate buildings to conform to the contour of the country and also for protection against fire.

The elevators and pumps for handling slimes, solutions and water are installed in duplicate to insure against stopping of the entire plant when making necessary repairs to these machines.

Direct Heat Rotary Dryers.

The American Process Company, 62-64 William Street, New York, is distributing an illustrated leaflet describing its improved direct-heat rotary dryers. This type of dryer is built especially to develop large capacity and to stand heavy work, having no castings, gears, etc., and the friction driving wheels and bearing bands are made of forged steel. The continuous action of these dryers is an important feature that should not be overlooked.

The wet material is fed in at one end continuously, while the dried stuff is delivered continuously at the other end; thus no time or labor is lost in charging or discharging the machines, which in many cases is far greater than that required for the actual process of drying. As the power required to start machinery is always greater than is required to keep it in operation, it will be seen that this apparatus requires smaller power units and driving machinery than intermittent dryers.

The direct-heat principle is another important feature. The capacity of air and gases for carrying off moisture increases enormously in proportion to the fuel consumed where the higher temperatures are used. In this system the company employs this principle to the fullest extent without any injury to the material undergoing drying, and it guarantees high efficiency of evaporation on delicate material.

For handling coal or other combustible material, running low in moisture, the dryer is similar to Figs. 1 and 2. The furnace is designed with air chamber between combustion chamber and shell. A forced-draft blast pipe is branched to both ash pit and air chamber, and by blast gates the air supplied to these two points can be regulated and the temperature of the gases entering the shell can be controlled. For ordinary material, or even for coal running high in moisture, the air chamber is eliminated. The high temperature gases then come in contact with the wettest material, thus at once reducing the temperature of the gases, and as the material becomes dry the gases are constantly falling in temperature and are drawn off at the discharge end of dryer thoroughly saturated, at about 350° temperature.

For calcining or roasting this process is reversed, the material passing in the opposite direction to that of the gases and discharging at the furnace end. This, however, is not a drying, but more of a calcining or roasting process.

These machines are handling by-products from chemical plants, such as sulphate of lime, carbonate of lime, grape pomace from the manufacture of tartaric acid, etc. They are also handling packing-house tankage, blood, fish scrap, brewer's grains, refuse hops from breweries, phosphate rock, Fuller's earth, and, in fact, any and all material that is being mechanically dried.

The moving parts are very few, and so constructed that the wear is small and entirely confined to parts easily repaired or replaced at small cost. All working parts are exposed and can be watched by the operator without taking him from other duties.

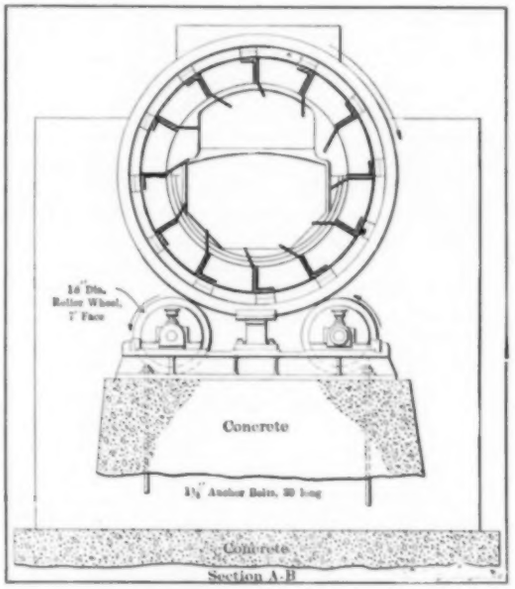


FIG. 1.—CROSS-SECTION OF ROTARY DRYER.

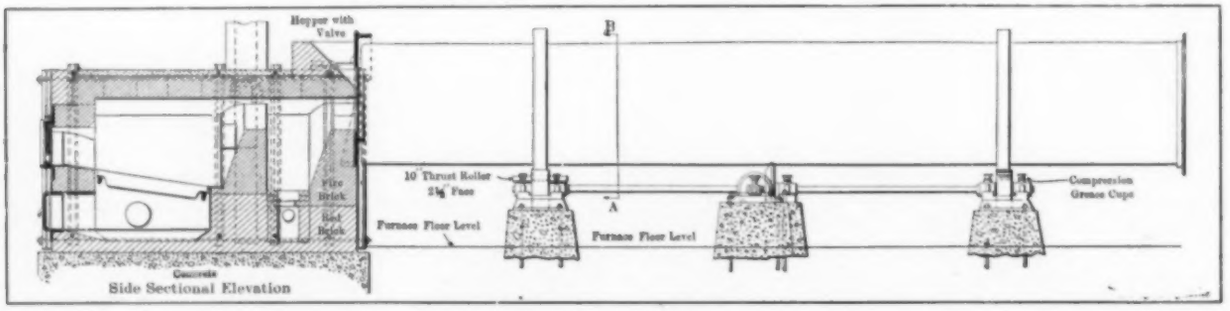


FIG. 2.—LONGITUDINAL SECTION OF ROTARY DRYER.

Iron Deposits of Cuba.

In former notes on the large deposit of iron ore in the Mayari district of Cuba, which has been under development by the Spanish-American Iron Company since January, 1904, it has been stated on the basis of estimates of the engineers of the company that the deposit contains more than 500,000,000 tons of ore carrying above 40 per cent iron. The importance of the low-grade iron ores of Cuba is emphasized in a paper by Mr. Arthur C. Spencer, just published by the United States Geological Survey as an advance chapter from Bulletin No. 340. In this paper Mr. Spencer discusses briefly the deposits of the Mayari field and of two other Cuban iron-ore districts, the Moa and Cubitas fields.

The Moa and Mayari districts are near the north coast of Oriente Province, or Santiago de Cuba. The Cubitas field is in Camaguey Province, formerly Puerto Principe, midway between the city of Camaguey and the north coast of the island. The aggregate amount of iron ore available in these three districts is roughly estimated at about 1,500,000,000 tons.

In physical character and manner of occurrence the ores of

the three provinces are practically identical and are very different from the well-known iron ores occurring in the Sierra Maestra near the south coast of Oriente Province. The Cuban ores that have been mined up to the present time are hard hematites with an admixture of magnetite, containing rather high sulphur and a small amount of copper.

The ores of the Mayari type come under the general head of limonite, and occur in blanket form as a superficial mantle covering massive serpentine and related rocks. Average analyses show nearly 2 per cent of chromium, rather high alumina, very low sulphur, and phosphorus below the Bessemer limit. Iron, ranging from 30 to 50 per cent, is usually above 40 per cent.

The Republic of Cuba has inherited mining laws based on the principle that the ownership of all deposits of metallic minerals is inseparable from the State. In the case of iron ores, concessions of any desired size may be acquired from the government by a process known as denouncement, the expense, including attendant surveys and title of concession, amounting to $2.86 per hectare, equivalent to 2.47 acres. The law provides for the payment of an annual tax of $2.50 per hectare, nonpayment of which is the only cause of forfeiture. Collection of this charge has been suspended since 1901, so that at the present time mining rights, once secured by a small expenditure, may be held without further cost.

Where the surface rights to land containing mineral deposits are held by private interests arrangements must be made to satisfy all damages which may ensue, but in the case of wild or forest lands owned by the government the concessionary apparently acquires full surface rights with the title of concession. This fact is of great importance both at Moa and Mayari, where large tracts which have been held by the Church of Rome became government lands when the republic was established. With the exception of a few small claims at Moa, all the ore lands in the Moa and Mayari districts have been denounced within the last four years, so that in these districts titles are likely to be clear. In the Cubitas district most of the denouncements were made many years ago, and some of these titles to ownership are more or less clouded.

Notes.

Carborundum Industry in Europe.—According to an article of Jean Escard, in *La Lumière Electrique*, of March 7, a new carborundum plant will be started in Bodio, Turin, Italy. Older European carborundum works are said to be located at La Bathie, in Savoi (since 1894), and at Benateck, in Bohemia. We may add also the Deutsche Carborundum Werke, in Düsseldorf-Reisholz, Germany.

Copper Industry.—As an indication of a return to activity in the copper mining districts of the West, a large contract for mining machinery recently let to Allis-Chalmers Company, of Milwaukee, Wis., is of more than ordinary interest. This contract comprised an equipment for converting copper matte into blister copper, consisting of two electrically-operated converter stands with six converter shells, for the Yampa Smelting & Refining Company, Bingham, Utah. These converters are the latest improved Allis-Chalmers type, 84" x 126". The contract includes the furnishing of all accessories, such as copper molds and cars, ladles, tamping machinery, a complete silica crushing plant for converter lining, with electric motors, and a cross-compound blowing engine for furnishing blast to the converter.

Dr. John E. Teeple has resigned as director of the Industrial Laboratories, vice-president of the Binns Chemical Works and vice-president of The Charles E. Sholes Company, and will devote his entire time to consulting chemical work and chemical engineering. Dr. Teeple's offices are located at the Hudson Terminal, 50 Church Street, New York City.

Messrs. C. F. Boehringer & Soehne of Mannheim, Germany, have discontinued their branch house in New York and have placed in the hands of Messrs. Merck & Co., of New York and St. Louis, as their sole agents, the marketing of their B. & S. quinine and B. & S. cocaine and all other B. & S. chemicals.

Mr. Frederick F. Schuetz has moved his New York office to Room 1352 of the new Hudson Terminal Buildings, 50 Church Street, where he will continue his business as solicitor of U. S. and foreign patents, trade-marks, designs, etc.

The International Acheson Graphite Company in Niagara Falls, are about to make very important additions to their works. Ground has already been broken for a new switchboard building, while a new furnace building, 120 ft. long by 100 ft. wide, with room for 12 new furnaces, and a new grinding and storage building will also be erected. The capacity of the works will thereby be doubled. In spite of the present general industrial depression, the Acheson Graphite Company is now exceedingly busy, more orders having been received in the first quarter of 1908 than in the corresponding period in 1907. Much of this activity is due to the general interest which deflocculated graphite has aroused in the various industries which are concerned with its commercial applications.

The Goldschmidt Thermit Company announces the establishment of an office and works at 103 Richmond Street, W., Toronto, Canada. The new branch was opened for business on May 1, and is under the management of Mr. E. C. Rutherford, of Toronto. A complete stock of thermit and appliances will at all times be carried at Toronto, and the branch organization will be in a position to execute promptly the welding of heavy steel sections, such as stern posts of steamships, crank shafts, etc., as well as trolley rails in paved streets, motor cases, and other broken steel sections. A fully equipped repair shop will be in operation for the repair of steel castings up to one thousand pounds in weight.

United States Dry Galvanizing Company.—On May 12 a meeting of the stockholders of the United States Dry Galvanizing Company was held in New York City for reorganizing the company. The following directors were elected: W. C. Robinson, H. H. Robinson, J. H. Clapp, C. E. Corrigan, J. Norman Martin, C. J. Kirk and H. V. Simpson. Immediately following this meeting a directors' meeting was held at which the following officers were elected: C. J. Kirk, president; W. C. Robinson, vice-president; H. H. Robinson, secretary and treasurer. The company proposes to take active steps for the immediate introduction of the dry galvanizing or Sherardizing process which has been noticed in these columns (on page 187 of our Vol. V and on page 191 of our last issue). The main office of the United States Dry Galvanizing Company will be at New Castle, Pa.

The Power and Mining Machinery Company announces that their San Francisco office has been removed to Room 217, Sheldon Building.

The Schutte & Koerting Co., manufacturers of steam and engineering specialties for chemical works and other industries, have moved their New York sales office, where they are represented by Mr. S. C. Smith, from 26 Cortlandt Street to Hudson Terminal Building, 50 Church Street. Their new catalogue of chemical works equipment, composed of bulletins of special engineering appliances used in chemical works and allied industries, is probably one of the most up to date and complete so far published by any engineering firm. This will be sent on request to engineers interested in this subject.

Messrs. Baker & Co., manufacturers of platinum ware for all purposes, with main offices and works at Newark, N. J., have moved their New York office from 120 Liberty Street to Hudson Terminal Building, 30 Church Street. The new offices are more commodious than those at the old address, and the convenience of location will easily be appreciated.

The Technical Publicity Association has elected the following officers for the ensuing year: Mr. C. T. Redfield, president; Messrs. Rodman Gilder and C. N. Manfred, vice-presi-

dents; Mr. H. H. Kress, secretary; Mr. H. M. Davis, treasurer; Messrs. F. H. Gale and C. W. Beaver, members of executive committee.

Electrolysis for High Art.—In a recent issue of Lond. *Electrician* we note that an English company is employing an electrolytic process which not only allows original bas-reliefs or art metal work to be reproduced, but permits new designs to be executed in a cheaper and more expeditious way than by hammering or casting. It is said that excellent results are obtained and photographs are given of silver reliefs of portraits of Faraday and Lord Kelvin. The scope of art metal work is very wide, extending as it does from the most artistic production to the humble but necessary bed knob, to the manufacture of flush switch plates, ornamental domes for surface switches, door plates and knobs, bell-push covers, etc., all in complete sets in English and French styles. No technical details of the process are given.

Ferro Alloys.—We have received from George G. Blackwell, Sons & Company, Ltd., Liverpool, England, the fifth edition of their interesting booklet on electric-furnace high-grade alloys. It deals with the chief properties imparted to steel by the alloying elements, notably chromium, tungsten, molybdenum, vanadium, titanium, silicon and manganese. Since the fourth edition of this booklet was reviewed at great length in our Vol. IV, p. 247, we will note here only what is new in the fifth edition. As to chrome-steel reference is made to Mr. Hadfield's remark that there is a future for chrome steel with low carbon. Such a tough steel is badly wanted for wire ropes, bicycle spokes and sundry other similar materials where high tensile strength and ductility are essential. Chrome-steel has also desirable properties for electromagnetic purposes. The coercive force, especially when the material is hard, is great. Dr. Hopkinson considers that it should make good permanent magnets, which is confirmed by Dr. Bottomley's tests. (Mr. R. A. Hadfield's Iron and Steel Institute paper on alloys of iron and chromium is still the classical exposé of the subject.) It has been known in the past that boron has been experimented with by steel makers, but for what special purposes it is good has been more or less of a mystery. Messrs. Blackwell's pamphlet speaks about this as follows: "Some years ago we were asked to produce an alloy of boron and iron by one of the famous Continental steel works, and we finally succeeded in producing an alloy with 30 per cent. boron. Some important experiments with boron steels have been made, both alone and alloyed with other metals. Boron would appear to replace carbon, and produce borides of iron instead of carbides of iron. This opens up new theories in the metallurgy of steel, and the subject appears worthy of fuller investigation." The Blackwell ferroboron analyzes 32.75 Bo, 2.875 C., 0.03 S, and 0.005 P. The remarkable parallelism between the work on new metallic filaments for incandescent lamps and the use of the same elements in the steel industry is again emphasized by the fact that after the tantalum lamp has become a commercial product, ferrotantalum is now placed on the market for the steel maker. "Extensive experiments have been made by steel manufacturers with the use of tantalum in steel. This metal imparts extreme hardness to steel, and its effect under various conditions and in various percentages of tantalum, alone and also alloyed with other steels, is being very carefully investigated." The Blackwell ferrotantalum contains 65 to 75 per cent. of tantalum. The concluding pages of the pamphlet deal with other specialties of George G. Blackwell, Sons & Company, Ltd., especially their "high-speed steel alloy," their "S. A. M. alloy," fluorspar and various foundry specialties.

Geological Chemistry.—A notable work has been issued as a publication by the United States Geological Survey, a bulletin entitled "The Data of Geochemistry," No. 330 of the Survey's series, by Prof. F. W. Clarke, the chief chemist. The various chemical changes taking place in the crust of the earth, with its liquid and gaseous envelopes, the ocean and the atmosphere, are the field of investigation of the geological chemist. From a geological point of view the solid crust of the earth is the chief object of his study, and the reactions which take place in it he classes, for convenience, under three heads: First, reactions between the essential constitution of the crust itself; second, reactions due to the aqueous envelope, and, third, reactions produced by the atmosphere. That the three classes are not sharply defined, but grade into one another, is admitted, but the distinction between them is valid enough to serve a good purpose in the arrangement and discussion of the data. Furthermore, for convenience of study, the solid crust of the earth may be regarded as made up of three layers or shells, which interpenetrate one another to some extent, but which are, nevertheless, definite enough to be considered separately. The innermost is a shell of crystalline rocks, of unknown thickness, which forms the nearest approach to the original material of which the crust was composed; next overlying this is a shell of sedimentary or fragmental rocks; and above this is the third layer of soils, clays and gravels. The second and third layers are relatively thin and are derived chiefly from the first, in great part through the transforming agency of waters and of the atmosphere, although organic life has had some share in bringing about certain of the changes. It is the history of these innumerable changes which Prof. Clarke has presented in his report. Upon the subject of geochemistry, a vast literature exists, but it is widely scattered and portions of it are difficult of access. To bring some of the data together, to formulate a few of the problems, and to present certain of the conclusions in their modern form, are the purposes which Prof. Clarke had before him in the preparation of his memoir. "It is not an exhaustive monograph upon geochemistry, but rather a critical summary of what is now known, and a guide to the more important literature to the subject. If it does no more than to make existing data available to the reader, its preparation will be justified."

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

690,319, dated Dec. 31, 1901, Isaiah L. Roberts, of Brooklyn, N. Y.

Feeds a mixture of lime and carbon, or bricks or cylinders of compressed lime, carbon and a binder, such as bitumen, asphalt, pitch or syrup, downward into an arc sprung between the lower ends of converging carbon-plate electrodes. The ends of the electrodes are raised to a white heat, and the heated charge may carry current, being then heated both by the arc and resistance. The molten carbid drops into a lower chamber closed by a gate-valve. This chamber is filled with an inert gas, taken, for example, from the zone of reduction. The plate electrodes are pivoted at their upper ends and the arcing distance between their lower ends is adjusted by screws.

701,650, dated June 3, 1902, Douschan de Vulitch and Jules D'Orlowsky, of Paris, France.

Produces porous calcium carbid, impregnated with a hydrocarbon, by running molten lime, or a mixture of lime and carbon, from an electric or other furnace into a heavy hydrocarbon liquid, for example, petroleum residues, mineral or natural tar, resin or pitch. The hydrocarbon reduces the oxid and produces carbid which, while cooling and crystallizing, is completely penetrated by the hydrocarbon in which it is immersed. The hydrocarbon also transforms any phosphorous compounds into other volatile compounds which escape. The product is suitable for the generation of acetylene, but is not acted on by damp air.

* * *

This concludes the patents on Calcium Carbide. All the patents on this subject will be found on pages 154, 198, 248, 292, 336, 382, 430, 480 and 516 of our Vol. V and on pages 39, 86, 132, 170, 218 and 264 of our Vol. VI. In the next number the instalment on Electric Furnaces will begin.

NEW BOOKS.

THE STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS. Written and compiled by a staff of specialists. Second edition—corrected. Sixth thousand, 1908. Over 1300 pages, 1300 illustrations. Flexible leather binding. Thumb index. Price $4. New York: McGraw Publishing Co.

"The new edition is not only ¼ inch thinner, but lighter than the first edition, on account of a better and thinner quality of paper used. The book is now of truly pocket size. Thumb index tabs are provided; while these are of little use in ordinary handbooks, yet in this particular book the system of indexing is very greatly improved by the use of tabs at the beginning of each section, giving the number of the section. The system of referring to sections and paragraphs when used in conjunction with thumb tabs, has a distinct advantage over the usual system. Five thousand copies of the first edition were sold in three months and the handbook was officially adopted as a text in 30 engineering schools and colleges."

THE CHEMISTRY OF THE DIAZO-COMPOUNDS. By J. Cannell Cain. 182 pages. Bound in cloth. Price, $3 net. New York: Longmans, Green & Co.

MODERN PIGMENTS AND THEIR VEHICLES. By F. Maire. Their properties and uses, considered mainly from the practical side, and how to make tints from them. 266 pages, illustrated. Bound in cloth. Price, $1 net. New York: John Wiley & Sons.

THE CHEMICAL BASIS OF PHARMACOLOGY: An introduction to pharmacodynamics, based on the study of the carbon compounds. By F. Francis and J. M. Fortescue-Brickdale. 390 pages. Bound in cloth. Price, $4 net. New York: Longmans, Green & Co.

TESTING MILK AND ITS PRODUCTS. A manual for dairy students, creamery and cheese factory operators, food chemists, and dairy farmers. By E. Farrington and F. W. Woll. 18th revised and enlarged edition. 300 pages, illustrated. Bound in cloth. Price, $1. Madison, Wis.: Mendota Book Co.

A NEW PROOF OF THE PERMEABILITY OF CELLS FOR SALTS OR IONS. (A preliminary communication.) By Jacques Loeb. 86 pages. Paper binding. Berkeley, Cal.: University of California Press.

AMERICAN INSTITUTE OF MINING ENGINEERS. General alphabetical and analytical index. Transactions V. 1-35 (1871-1904). 79 pp., 626 pp., $5; half-morocco, $6. New York: Am. Institute of Mining Engineers.

A POCKET HANDBOOK OF MINERALS designed for use in the field or class-room, with little reference to chemical tests. By G. M. Butler. 307 pages, illustrated. Bound in leather. Price, $3. New York: John Wiley & Sons.

INTRODUCTION TO METALLOGRAPHY. By Paul Goerens; translated by Fred Ibbotson. 224 pages, illustrated by diagrams. Bound in cloth. Price, $2.50 net. New York: Longmans, Green & Co.

DECORATION OF METAL, WOOD, GLASS, ETC. By H. C. Standage. Book of recipes for all workmen in the fancy trades. 228 pages. Price, $2 (8s. 6d.). New York: John Wiley & Sons.

MODERN ELECTRICAL THEORY. By Norman R. Campbell. 232 pages, illustrated. Bound in cloth. Price, $2.25 net. New York: G. P. Putnam's Sons.

THE MATHEMATICAL THEORY OF ELECTRICITY AND MAGNETISM. By Ja. H. Jeans. 544 pages. Bound in cloth. Price $4.50 net. New York: G. P. Putnam's Sons.

PRACTICAL CALCULATIONS FOR ENGINEERS; for the use of engineering students, apprentices, draughtsmen, mechanics, foremen and others practically engaged in engineering work. By C. E. Larard and H. A. Golding. 468 pages, illustrated by diagrams and tables. Bound in cloth. Price, $2 net. Philadelphia: J. B. Lippincott & Co.

NOTES ON PRACTICAL MECHANICAL DRAWING; written for the use of the students in general engineering drawing in the University of Illinois. By V. T. Wilson. 183 pages, illustrated. Bound in cloth. Price, $1.50. State College, Pa.: V. T. Wilson.

ENGINEERING REMINISCENCES CONTRIBUTED TO *Power* AND *American Machinist*. By C. T. Porter. Revised and enlarged. 347 pages, illustrated. Bound in cloth. Price, $3 net. New York: John Wiley & Sons.

WORLDS IN THE MAKING. The evolution of the universe. By S. A. Arrhenius. Translated by H. Borns. 244 pages, illustrated. Bound in cloth. Price, $1.60 net. New York: Harper Brothers.

BOOK .REVIEWS.

STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS. Twenty sections. By R. C. Beardsley, Louis Bell, H. M. Hobart, Otis Allen Kenyon, Edward Lyndon, A. S. McAllister, Kempster B. Miller, William H. Onken, E. F. Roeber, George Shaad. Bound in flexible morocco; over 1300 pages and 1260 illustrations. Price, $4 net, postpaid. New York: McGraw Publishing Company.

Every electrical engineer has a standard of his own by which he judges the value of an electrical handbook. An opinion of the individual, therefore, is not necessarily a good estimate of average value.

Perhaps a joint statement of what authors of engineering handbooks attempt to accomplish is to present in a suitably bound, conveniently arranged book of a thousand pages a compilation of data, tables and curves and a summation of laws and principles and their application to technology which shall be most serviceable to the practicing engineer. If this has been the attempt of the authors of the Standard Handbook of Electrical Engineers, they have succeeded admirably. The 1280 pages contain live, useful matter, based upon American practice. The subject matter is conveniently and originally divided into various branches of electrical technology, and 75 of the total number of pages are devoted to an index which adds greatly to the usefulness of the book.

It is evident that the field of electrical engineering has attained such proportions that a handbook pertaining to it must necessarily omit much of the matter which is commonly found in engineering handbooks, and it is significant to note that in this handbook but 10 pages are devoted to logarithmic and other mathematical tables.

The fact that it is difficult for one man to be intimately conversant with all branches of electrical engineering undoubtedly justified the editors of this book in enlisting the co-operation of various authorities in entering into a plan of joint authorship. This plan has resulted in various features not commonly found in engineering handbooks, though it is not perfectly clear that the advantages of this plan are not to some extent counterbalanced by disadvantages. An engineer, in compiling data and information relating to his particular specialty, can write with an authority which a compiler cannot possess, and that most of the authors of this book have done this is evidenced by the fact that comparatively few references are given to the important engineering and scientific publications, to which those wishing to go more deeply into a subject can refer. A notable exception is found in the chapter on electrochemistry, in which reference to current technical scientific literature is frequently made.

A handbook compiled by a single author may possess a consistency in the treatment of various branches which cannot be secured in a plan of joint authorship, and he is less inclined to draw upon his personal note-book and has a greater willingness to credit the material which he gives to original sources.

The lack of references, however, is a feature which may not be considered a defect by many engineers who may prefer to place implicit trust in the statements and data given by the handbook to which they are accustomed to refer.

In the Standard Handbook of Electrical Engineers there is some difference in the treatment by the different authors of different subjects, though, on the whole, there is evidence of good "team work" among the experts who have made this book.

Complying with the request which has been made of the reviewer to estimate the usefulness of this book, he has subjected it to a test which involved a record on a percentage basis of information actually found and of information which was sought, taking into consideration also the rapidity with which the book could be used. The resultant marking is high. The index, with its completeness and cross-references, is useful, though not perfect, as shown by the fact that to find in it the subject of "Meters," one must look under the head of Electric Instruments.

Costs enter so largely into engineering matters that the value of a handbook is largely enhanced by plenty of cost data. This has been recognized in the section of the book dealing with transmission and distribution, and to lesser extent in that dealing with telephony and some of the other branches, while the sections devoted to transformers, motors and batteries have no cost data.

Depreciation is a subject commanding attention among engineers at the present time, but no consideration is given it in this handbook.

This new handbook, while unavoidably possessing defects and limitations, should prove of great value, not only to the practicing American engineer, but to the student as well. The importance to the engineering profession of handbook literature is great, and the question, "What qualities shall the electrical handbook possess?" is a subject of sufficient importance for careful consideration on the part of electrical engineering societies.

C. F. Burgess.

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Annual Report of the Mint for the Fiscal Year Ended June 30, 1907. 281 pages. Washington: Government Printing Office. (Treasury Department, Document No. 2,493.)

This report contains the valuable annual statistical tables and data for the year ending June 30, 1907. It closes a period of service of more than nine years for the retiring director of the mint, Mr. Geo. E. Roberts. During these years the organization of the service has expanded to the extent of one new coinage mint, opened in 1906 in Denver, and one important assay office, opened in 1898 in Seattle.

The capacity of all the mints has been greatly increased by the introduction of new and improved machinery. The old mint at Philadelphia, built in the early thirties, has been replaced by a splendid new one, undoubtedly the finest building ever constructed for coinage uses, and it has been thoroughly equipped with machinery of the most approved type. The new mint at Denver, although of smaller capacity than the one at Philadelphia, has a thoroughly modern and perfect equipment.

Melting is now entirely done by gas. All machinery in the mints is driven by direct-connected motors. An automatic weighing machine has been developed which rapidly and accurately selects and assorts by weight all coin blanks. The most interesting technical development, however, has certainly been in connection with electrolytic refining of bullion. The report deals with this advance as follows:

"Contrary to the policy of the European mints, it has always been the practice here to conduct refineries in connection with coinage operations, being thus enabled to receive crude bullion.

"In 1908 the time-honored acid-parting methods were used in all the mints and in the assay office at New York. The partial suppression of acid fumes (it could be made only partial) was expensive and they remained a constant source of complaint from Wall street.

"In 1907 all parting and refining is done by electrolysis. Experiments in refining gold by the electric current were conducted by the melter and refiner of the mint at Philadelphia as early as 1898, with such satisfactory results that a plant for actual work was about to be installed when an inspection of the records of the Patent Office showed that his process was covered by a patent issued to Dr. Emil Wohlwill, of Hamburg, Germany. The facts were reported to the Mint Bureau and negotiations opened with the patentee which resulted in the purchase of a right to use the process in the mint at Philadelphia. A small plant was installed in the old mint, and in August of the year 1900, 20,000 ounces of electrolytic refined gold was produced of almost absolute purity.

"Experiments looking to an equally efficient method for refining silver were prosecuted, but the problem here was a more difficult one, since in the parting of mint deposits considerable quantities of base metal have to be reckoned with, such as copper, lead, etc. In the Moebius process, then coming into extended use in private refineries, all bullion to be treated by electrolysis was and still is submitted to a preliminary cupellation, by which it was brought to so-called Dore bars, consisting of practically pure silver, with only a small percentage of gold as an impurity. The problem in mint practice was to adapt the electric current to the quartation process—that is, to *part* bullion containing, say, one-third gold and two-thirds silver and base metals. To have accomplished this result and on a large scale reflects great credit on the melting and refining department of the mint at Philadelphia. Only an untiring devotion to the work, directed by high scientific training, could have produced the results which have been realized. Parting and refining is now done entirely by electrolysis in the mints at Philadelphia and Denver. The process had a successful trial in the assay office at New York, and will be installed in the new structure, now in process of building on Wall street. The acid plant in the mint at San Francisco is now being replaced by one in which electricity is to do the work of tons of acids.

"The gradual stages through which this revolution of methods has passed have been detailed in previous reports and find no place here. A great saving has been effected in the cost of parting and refining; valuable by-products, principally platinum, are recovered in important quantities. The refined metals, gold and silver, are almost chemically pure; the acid fumes are eliminated, and the process is a cleanly, healthy one, of scientific as well as commercial interest. Surely such results mark an era in mint methods." (More detailed technical descriptions of these electrolytic processes may be found in our Vol. I, p. 157; II, pp. 221 and 261, and IV, p. 306.)

There were received and operated upon by the refineries connected with the mints at Philadelphia, San Francisco, New Orleans and Denver, and the assay office at New York, during the fiscal year 1907, gold bullion containing 8,179,555.581 standard ounces, and silver bullion containing 19,430,818.18 standard ounces, with values of $152,177,778 and $22,610,407, respectively.

The earnings of the refineries were $230,089 for charges collected, $32,584 for surplus bullion and $71,240 from by-products, hence the total earnings $333,913, while the expenses were $246,817, showing a net gain of over $87,000.

The deposits of gold bullion at the mints and assay offices of the United States during the fiscal year 1907, exclusive of the redeposits, were of the value of $176,580,654.53, against $153,109,493.52 reported the previous year. Redeposits, which consists of bullion transferred from one office of the service to the other, or bars bearing the stamp of one of the offices of the service, amounted to $65,118,805.02.

The aggregate of all deposits, including redeposits, is the total metal operated upon in the year by the mint service. This total of gold bullion received in the fiscal year 1907 was 12,991,346.109 standard ounces of the value of $241,699,459.55, against 10,045,282.710 standard ounces of the value of $186,888,975.26 reported the previous year.

The deposits of domestic bullion amounted to 6,139,183.740 standard ounces, of which 1,941,006.290 standard ounces were in crude condition direct from the mines operating in the different States; 701,105.411 standard ounces of refinery bars (less than 0.992 in fineness), and 3,497,077.039 standard ounces of refined bullion (0.992 in fineness and over) were received from private refineries, bromide, chlorination and cyanide works.